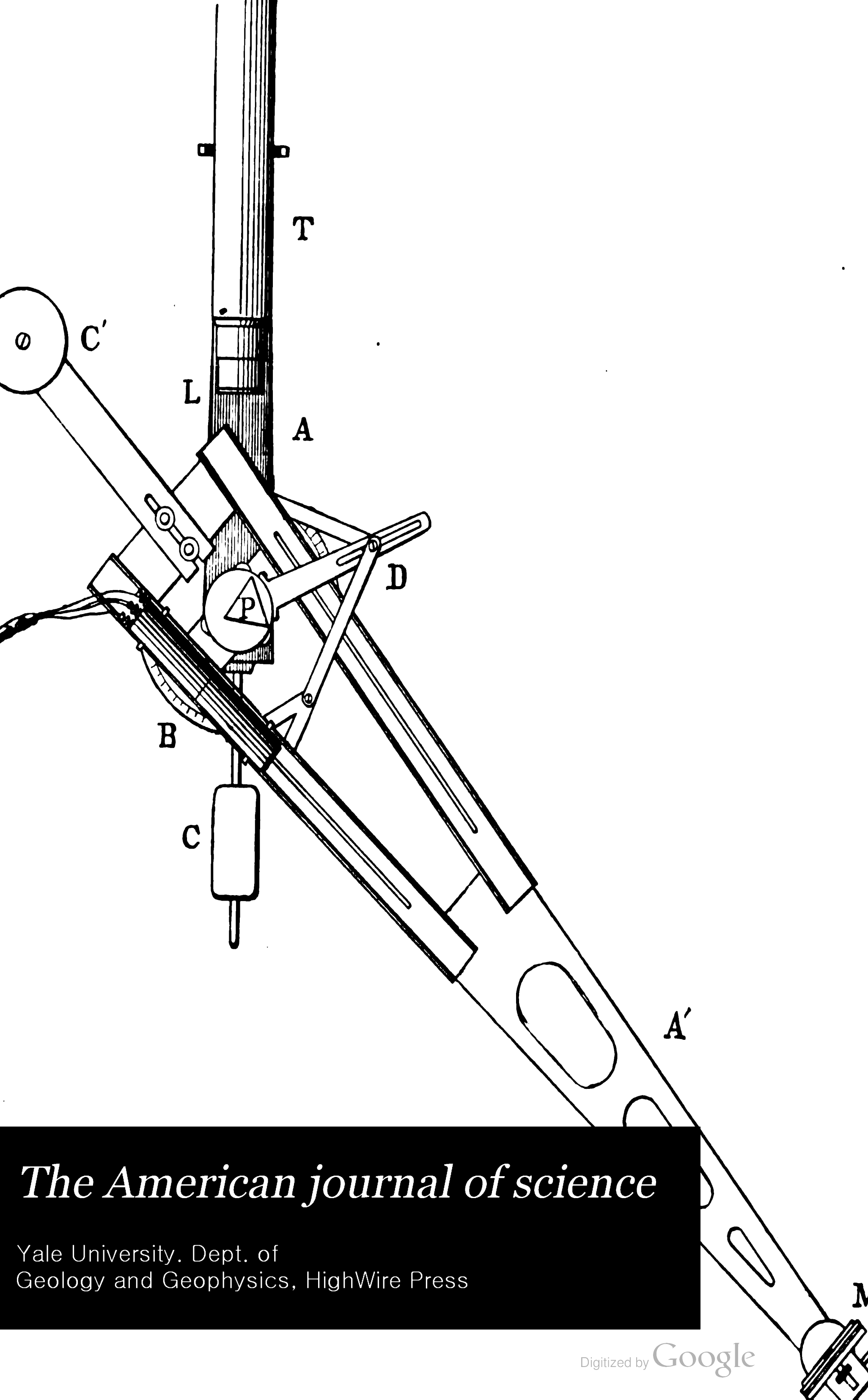

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ERRATA.

Page 82 (January), 5th line from bottom, read "obviously *no* more."
Page 83, lines 21 and 22, for "Ford" read "*Forel.*"
Page 326, line 3 from top, for $2^h\ 30^m\ 46^s$ read $2^h\ 39^m\ 49^s$.
Page 326, line 4 from bottom, for 'section' read 'second.'
Page 328, line 4 from top, for $64''\cdot43$ read $64''\cdot13$.
Page 330, in title, for Wm. F. Fontaine read Wm. M. Fontaine.

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THE

AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

ART. I.—*Contributions to Meteorology;* by ELIAS LOOMIS, Professor of Natural Philosophy in Yale College. Eighteenth paper. With a Map (Plate I).

[Read before the National Academy of Sciences, Nov. 14, 1882.]

Mean annual rain-fall for different countries of the globe.

MY sixteenth paper of "Contributions to Meteorology" contained a table showing the annual rain-fall for 713 stations from various parts of the globe, and also a chart showing the lines of equal rain-fall as well as I could determine them from the observations then collected. I however distinctly stated that for certain portions of the globe, and especially for the southern hemisphere, the observations were too few to enable us to draw the lines of equal rain-fall with confidence; and I requested that if any person should discover serious defects in my chart, he would communicate to me the observations which indicate these defects. In response to this request I have received communications from numerous sources, of which the following are the most important: The Meteorological Service of the Dominion of Canada; the Meteorological Institute of Norway; the United States Signal Service; Dr. Alexander Woeikoff of St. Petersburgh; Dr. A. von Danckelman of Leipzig; Dr. Benjamin A. Gould of Cordoba; Professor Orville A. Dewey of Rio de Janeiro; Dr. Mauricio F. Draenert of Bahia: and Henry B. Joiner of S. Paulo, Brazil. I have also received the published observations of rain-fall from a large number of

countries, of which those from Mexico, Japan, the East Indian Archipelago, and Australia, and those contained in the second edition of Schott's Rain Tables, have proved of the greatest value for my present purpose. I have carefully considered the criticisms which have been made upon my first paper, particularly those of Dr. Woeikoff (this Journal, May, 1882) and those of the editor of Nature (June 29, 1882).

The accompanying table shows the most important observations which I have thus far received, many of them being from new stations, while those from stations included in my former paper exhibit the results of a more extended period of observation. Column 1st contains the reference number; column 2d gives the name of the station; column 3d gives its elevation above the sea expressed in English feet; column 4th gives the latitude of the station and column 5th its longitude from Greenwich; column 6th shows the number of years of observation represented; column 7th shows the mean annual rain-fall expressed in English inches; and column 8th gives the authority for the results. In the last column, Schott's T. 2d ed. stands for Tables of the precipitation in rain and snow in the United States, by Charles A. Schott, 1881; Bol. Met. Mex. stands for Boletin Meteorologica Mexicana; Revista Ci. Mex. stands for Revista Cientifica Mexicana; Rev. de Engenh. stands for Revista de Engenharia; S. Paulo Rw. Co. stands for São Paulo Railway Company; Zeitsch. stands for Zeitschrift der Österreichischen Gesellschaft für Meteorologie; En. Met. Com. 28 stands for Contribution to the Meteorology of Japan No. 28, issued by the English Meteorological Committee; Q. J. Met. Soc. stands for Quarterly Journal of the London Meteorological Society; A. v. Danckelman stands for Meteorologischen Beobachtungen von Dr. A. von Danckelman; Russ. Met. Obs. stands for Russell's Rain Observations in New South Wales. The other abbreviations will probably be understood without particular explanation. This table might have been very much enlarged, but I have confined myself to those stations which were regarded as specially useful in revising my rain-chart. With the aid of the new materials thus collected I have prepared a new chart of the rain-fall which is believed to represent pretty well all the observations contained in my two tables.

If these two charts are carefully compared, a general resemblance will be readily perceived, particularly in the Northern Hemisphere. In North America there is a little change between Lake Superior and Hudson Bay; also in Yucatan and Central America. In South America the changes are much greater. The observations from the Argentine Republic indicate that the line of 50 inches rain-fall crosses the meridian of 60° in about latitude 27½° S.; and although the number of ob-

Mean Annual Rain-fall for various Stations.

No.	Station.	Elev. feet.	Lat.	Long.	Years Obs.	Rain. Inches.	Authority.
1	Fort Peel's River	--	67° 32′ N	134° 30′ W	2½	53·88	Schott's T., 2d ed.
2	York Fact'y, Hud. B.	55	57 0 N	92 26 W	4	24·73	'anada Met. Obs.
3	Dunvegan, N.W.Ter.	1000	56 0 N	118 20 W	-	15·26	Can. Met. Office.
4	Belle Isle	405	51 53 N	55 22 W	-	55·07	do.
5	Lillooet, Brit. Col.	--	50 42 N	122 2 W	3	15·26	Canada Met. Obs.
6	Spence's Bridge, B.C.	760	50 25 N	121 30 W	4	10·14	do.
7	Nicola Lake, Br. Col.	2100	50 16 N	120 43 W	3	11·99	do.
8	Meadow Lea, Man.	825	50 7 N	97 40 W	-	24·64	Can. Met. Office.
9	Ossowa, Manitoba	--	50 6 N	98 15 W	-	27·14	do.
10	Poplar Heights, Man.	--	50 5 N	97 50 W	2	25·45	Canada Met. Obs.
11	Rockwood, Manitoba	--	50 5 N	97 12 W	2	17·60	do.
12	Mazatlan, Mex.	249	23 11 N	106 0 W	2	45·91	Bol. Met. Mex.
13	Zacatecas, Mex.	8187	22 44 N	102 33 W	3	25 65	do.
14	San Luis Potosi, Mex.	6202	22 9 N	100 58 W	3	16·30	do.
15	Pabellon, Mex.	6314	22 4 N	102 11 W	3	20·82	do.
16	Leon, Mex.	5901	21 6 N	101 30 W	3	28·26	do.
17	Guanaxuato, Mex.	6761	21 1 N	100 48 W	1	20·65	do.
18	Jalisco, Mex.	--	20 55 N	105 12 W	1	49·41	do.
19	San Juan del Rio	--	20 24 N	99 39 W	1	22·33	do.
20	Campeche, Mex.	--	19 54 N	90 24 W	1	45 56	do.
21	Teziutlan, Mex.	--	19 46 N	97 22 W	3	66·12	do.
22	Patzcuaro, Mex.	7015	19 31 N	101 31 W	2	44·77	do.
23	Mirador, Mex.	3600	19 15 N	96 40 W	12	83·86	Schott's T., 2d ed.
24	Puebla, Mex.	7112	19 3 N	98 11 W	3	40·24	Bol. Met. Mex.
25	Tuxpam, Mex.	--	19 0 N	97 7 W	3	59·61	do.
26	Colima, Mex.	1664	18 46 N	103 20 W	12	41·73	Revista Ci. Mex.
27	Tlacotalpam, Mex.	11	18 37 N	95 39 W	2	90·28	Bol. Met. Mex.
28	Oaxaca, Mex.	5072	17 3 N	96 40 W	3	30·21	do.
29	Aspinwall, N. Gren.	7	9 23 N	79 53 W	6	121·60	Schott's T., 2d ed.
30	Heredia, Costa Rica	3837	10 0 N	84 0 W	1	47·64	do.
31	Caracas, Venezuela	2923	10 31 N	66 55 W	1	37·01	Smith. Rep., 1867.
32	Medellin, Colombia	--	6 38 N	76 35 W	2	63·36	Sig. Ser. Int. Obs.
33	Paramaribo	--	5 49 N	55 12 W	2	91·03	do.
34	Manaos, Brazil	121	3 8 S	60 0 W	1	55·20	Zeitsch., viii, 267.
35	Fortalera, Ceara	--	3 43 S	38 29 W	28	58·62	W. M. Roberts.
36	Iquitos, Peru	320	3 44 S	73 8 W	1½	103·28	Schott's T., 2d ed.
37	Pernambuco	10	8 4 S	34 52 W	4	108·40	Zeitsch, xiv, 216.
38	S. Bento das Lages	98	12 37 S	38 40 W	1½	80·80	Rev. de Engenh.
39	Bahia, Brazil	--	13 0 S	38 32 W	1	83·08	do.
40	Sabara, Brazil	2280	19 54 S	44 30 W	25	64·45	W. M. Roberts.
41	Rio de Janeiro, Brazil	--	22 54 S	43 8 W	17	43·78	do.
42	S. Paulo, Brazil	2393	23 33 S	46 37 W	3	53·23	Henry B. Joyner.
43	Serra do Cubatao	2625	23 45 S	46 30 W	6	137·80	do.
44	Santos, Brazil	0	24 0 S	46 22 W	8	94·50	S. Paulo Rw. Co.
45	Alto da Serra	--	24 0 S	49 20 W	9	140·30	Prof. O. A. Derby.
46	Salta, Rep. Argentina	--	24 45 S	65 27 W	4½	27·01	Dr. B. A. Gould.
47	Villa Formosa, R. Ar.	--	26 12 S	58 5 W	2½	72·72	do.
48	Tucuman, Rep. Arg.	141	26 46 S	65 29 W	4½	35·40	do.
49	Corrientes, R. Arg.	--	27 19 S	58 56 W	7	58·58	do.
50	Pilciao, R. Arg.	--	27 30 S	66 36 W	5	39·17	do.
51	Santiago del Estero	--	27 44 S	64 23 W	6	19·92	do.
52	Goya, R. Arg.	--	29 12 S	59 22 W	6	46·22	do.
53	Saladillo, R. Arg.	--	29 S	67 W	3	17·87	do.
54	Rioja, R. Arg.	--	29 18 S	67 22 W	2½	11·93	do.
55	Curuzu Cuatia, R. A.	--	29 54 S	58 9 W	1½	51·46	do.
56	Villa Hernandarias	--	31 15 S	59 41 W	5	39·80	do.
57	Concordia, R. Arg.	--	31 23 S	58 2 W	3	46·10	do.

Mean Annual Rain-fall for various Stations.

No.	Station.	Elev. feet.	Lat.			Long.			Years Obs.	Rain. Inches.	Authority.
58	Cordoba, Rep. Arg.	1240	31°	25′	S	64°	11′	W	9½	27·80	Dr. B. A. Gould.
59	San Juan, Rep. Arg.	--	31	27	S	68	20	W	5	2·83	do.
60	Parana, Rep. Arg.	--	31	44	S	60	24	W	6	36·77	do.
61	Mendoza, Rep. Arg.	2559	32	53	S	68	52	W	4	7·15	do.
62	Rosario, Rep. Arg.	--	32	55	S	60	39	W	5	38·50	do.
63	Rio Cuarto, R. Arg.	--	33	7	S	64	21	W	1	29·21	do.
64	Nueva Palmira, R. A.	--	33	47	S	58	16	W	4½	27·24	do.
65	Tatay, Rep. Arg.	--	34	14	S	59	54	W	5½	33·78	do.
66	S. Antonio d'Areco	--	34	15	S	59	30	W	3	31·38	do.
67	Chacra Matanzas	--	34	25	S	58	26	W	5	36·58	do.
68	25 de Mayo, R. Arg.	--	35	20	S	62	0	W	1½	37·48	do.
69	Salado, Rep. Arg.	--	35	40	S	59	6	W	3½	30·94	do.
70	Dolores, Rep. Arg.	--	36	19	S	58	14	W	3½	33·27	do.
71	Tandil, Rep. Arg.	--	37	13	S	59	10	W	3½	34·45	do.
72	Bahia Blanca, R. Ar.	62	38	44	S	62	11	W	22	19·25	do.
73	Ushuaia, Rep. Arg.	--	54	53	S	68	10	W	3	19·72	do.
74	Alten, Norway	43	69	58	N	23	17	E	8	10·46	Dr. Henry Mohn.
75	Südvaranger, Norw.	66	69	40	N	30	11	E	7–8	14·39	do.
76	Tromsö, Norway	50	69	39	N	18	58	E	8–9	31·86	do.
77	Fagernes, Norway	25	68	27	N	17	28	E	8	19·72	do.
78	Lödingen, Norway	44	68	24	N	16	1	E	7	47·39	do.
79	Varö, Norway	39	67	41	N	12	37	E	2–3	24·19	do.
80	Bodö, Norway	15	67	17	N	14	24	E	12	32·39	do.
81	Ranen, Norway	43	66	12	N	13	32	E	8	39·74	do.
82	Brönö, Norway	35	65	28	N	12	14	E	8–9	32·65	do.
83	Ytteröen, Norway	249	63	49	N	11	14	E	9	21·04	do.
84	Christiansund, Norw.	50	63	7	N	7	45	E	18	33·47	do.
85	Röros, Norway	2064	62	35	N	11	23	E	7–8	15·73	do.
86	Aalesund, Norway	47	62	29	N	6	9	E	14	45·20	do.
87	Dovre, Norway	2110	62	5	N	9	8	E	10–11	14·30	do.
88	Domsten, Norway	36	61	53	N	5	40	E	5	74·02	do.
89	Florö, Norway	26	61	36	N	5	2	E	6	75·28	do.
90	Sogndal, Norway	109	61	18	N	7	3	E	9	27·97	do.
91	Flesje, Norway	16	61	8	N	6	27	E	8	52·75	do.
92	Grunheim, Norway	1251	61	6	N	8	58	E	8–9	21·35	do.
93	Leisdal, Norway	16	61	6	N	7	27	E	10	12·22	do.
94	Birid, Norway	419	60	58	N	10	35	E	5	23·86	do.
95	Bergen, Norway	57	60	24	N	5	20	E	14	72·24	do.
96	Eidsvold, Norway	615	60	22	N	11	13	E	10–11	30·84	do.
97	Ullensvang, Norway	35	60	20	N	6	40	E	6–7	39·69	do.
98	Hole, Norway	336	60	4	N	10	16	E	5	19·74	do.
99	Lauglien, Norway	926	60	4	N	10	31	E	6	41·08	do.
100	Bjomholt, Norway	824	60	3	N	10	39	E	--	42·02	do.
101	Christiania, Norway	80	59	55	N	10	45	E	42	26·93	do.
102	Aas, Norway	289	59	37	N	10	47	E	6	27·53	do.
103	Fredrikstad, Norway	18	59	13	N	10	56	E	3–7	31·60	do.
104	Valle, Norway	1039	59	12	N	7	32	E	3–4	36·80	do.
105	Skudesnes, Norway	13	59	9	N	5	16	E	14	42·84	do.
106	Sandösund, Norway	27	59	5	N	10	28	E	14	23·15	do.
107	Mandal, Norway	54	58	2	N	7	27	E	14	44·88	do.
108	Dalmatow, Russia	--	56	14	N	62	37	E	14	12·64	Dr. A. Woeikoff.
109	Astrakhan, Russia	55	46	21	N	48	2	E	32	5·71	do.
110	Low. Syr Daria, Rus.	--	46		N	62		E	5	5·12	do.
111	F. Alexandrowski, R.	--	44	27	N	50	8	E	13	4·49	do.
112	Alexandropol, Russia	5010	40	47	N	43	35	E	18	14·96	do.
113	Krasnovodsk, Russia	--	40	0	N	53	9	E	3	15·37	Met. Annalen.
114	Ura Tübe, Russia	--	41	30	N	68	13	E	1	12·95	do.

Mean Annual Rain-fall for various Stations.

No.	Station.	Elev. feet.	Lat.	Long.	Years Obs.	Rain. Inches.	Authority.
115	Taschkent, Russia	1588	41° 20′ N	69° 18′ E	8	12·28	Met. Annalen.
116	Samarkand, Russia	2378	39 39 N	66 57 E	1	13·54	do.
117	Pendshekent, Russia	3163	39 28 N	67 33 E	1	12·44	do.
118	I. Ashur Ade, Russia	..	36 54 N	53 50 E	6	17·80	Dr. A. Woeikoff.
119	Wernyj, Russia	2402	43 16 N	76 53 E	2	18·44	Met. Annalen.
120	Yokohama, Japan	..	35 27 N	139 40 E	4	85·27	En. Met. Com., 28.
121	Cape Sagami, Japan	..	35 8 N	139 41 E	4	48·14	do.
122	Awadji, Japan	..	34 37 N	135 0 E	3	38·13	do.
123	Rock Island, Japan	..	34 34 N	138 57 E	4	60·94	do.
124	Isumi, Japan	..	34 17 N	135 0 E	2	47·61	do.
125	Isaki, Japan	..	33 58 N	131 1 E	2	54·27	do.
126	Isauri Sima, Japan	..	33 53 N	132 38 E	1	28·16	do.
127	Oosima, Japan	..	33 28 N	135 52 E	4	71·43	do.
128	Siwo Misaki, Japan	..	33 26 N	135 46 E	4	64·78	do.
129	Nagasaki, Japan	..	32 43 N	129 46 E	4	40·64	do.
130	Saton Misaki, Japan	..	30 58 N	130 40 E	4	52·12	do.
131	Zikawei, China	..	31 12 N	121 26 E	8	42·44	Zeitsch., xvii, 16.
132	Hongkong, China	..	22 16 N	114 10 E	12	84·60	Zeitsch., viii, 72.
133	Manilla, Phil. Is.	..	14 36 N	120 40 E	19	75·05	Various sources.
134	Bangkok, Siam	..	13 43 N	100 25 E	10	67·04	Q J.Met.Soc. v,88.
135	Saigun, Siam	..	10 48 N	106 40 E	1	58·42	Zeitsch., vii, 23.
136	Bohol, Phil. Is.	..	9 55 N	124 32 E	2	49·47	Zeitsch., v, 69.
137	Linao, Phil. Is.	..	8 5 N	125 45 E	1	150·72	do.
138	Serang, Java	102	6 7 S	106 8 E	3	82·05	Dr.P.A. Bergsma.
139	Onrust, Java	..	6 1 S	106 46 E	3	71·50	do.
140	Batavia, Java	23	6 11 S	106 50 E	3	73·31	do.
141	M. Cornelis, Java	46	6 13 S	106 54 E	3	81·74	do.
142	Buitenzorg, Java	869	6 36 S	106 47 E	3	203·24	do.
143	Tjandjoer, Java	1542	6 49 S	107 8 E	3	114·10	do.
144	Telaga P., Java	5105	7 10 S	107 25 E	2	167·01	do.
145	Soekawana, Java	5062	6 45 S	107 38 E	3	115·95	do.
146	Soemedang, Java	1450	6 50 S	107 57 E	2	122·09	do.
147	Manondjaja, Java	810	7 20 S	108 20 E	2	131·34	do.
148	Tjilatjap, Java	0	7 44 S	109 0 E	2	161·64	do.
149	Kedong K., Java	148	7 41 S	110 2 E	3	115·16	do.
150	Madjalengka, Java	472	6 48 S	108 15 E	2	138·43	do.
151	Tegal, Java	0	6 51 S	109 8 E	3	77·72	do.
152	Pekalongan, Java	0	6 53 S	109 40 E	3	104·97	do.
153	Pelantoengan, Java	2273	7 6 S	109 59 E	3	192·98	do.
154	Semarang, Java	13	6 58 S	110 25 E	3	90·91	do.
155	Rembang, Java	0	6 45 S	111 20 E	3	56·30	do.
156	Toeban, Java	0	6 52 S	112 5 E	3	62·80	do.
157	Oenarang, Java	1027	7 8 S	110 23 E	3	206·16	do.
158	Willem I., Java	1562	7 16 S	110 24 E	3	99·81	do.
159	Salatiga, Java	1933	7 20 S	110 30 E	3	117·72	do.
160	Magelang, Java	1257	7 29 S	110 13 E	3	137·13	do.
161	Djokjokarta, Java	371	7 48 S	110 21 E	3	95·79	do.
162	Patjitan, Java	23	8 12 S	111 5 E	2	79·10	do.
163	Klatten, Java	692	7 42 S	110 35 E	3	91·85	do.
164	Bojolali, Java	1300	7 32 S	110 35 E	3	127·56	do.
165	Soerakarta, Java	302	7 34 S	110 49 E	3	95·00	do.
166	Madioen, Java	220	7 37 S	111 31 E	2	69·96	do.
167	Ngawi, Java	203	7 24 S	111 26 E	3	90·83	do.
168	Malang, Java	1476	7 57 S	112 38 E	3	97·05	do.
169	Modjokerto, Java	95	7 28 S	112 25 E	3	73·31	do.
170	Soerabaja, Java	0	7 14 S	112 44 E	3	73·00	do.
171	Grissee, Java	0	7 10 S	112 39 E	3	69·06	do.

Mean Annual Rain-fall for various Stations.

No.	Station.	Elev. feet.	Lat.	Long.	Years Obs.	Rain. Inches.	Authority.
			° ′	° ′			
172	Pasoeroean, Java	13	7 38 S	112 56 E	3	57·92	Dr. P. A. Bergsma.
173	Probolingo, Java	33	7 44 S	113 13 E	3	50·20	do.
174	Loemadjang, Java	177	8 7 S	113 14 E	2	68·35	do.
175	Besoeki, Java	7	7 43 S	113 41 E	3	52·28	do.
176	Sitoebondo, Java	262	7 41 S	114 2 E	3	50·95	do.
177	Maësan, Java	1214	8 0 S	113 50 E	3	109·65	do.
178	Banjoewangi, Java	16	8 13 S	114 23 E	3	58·98	do.
179	Bangkalan, Madoera	16	7 2 S	112 44 E	3	84·33	do.
180	Pamekasan, Madoera	0	7 10 S	113 30 E	3	70·12	do.
181	Soemenep, Madoera	0	7 3 S	113 54 E	3	68·23	do.
182	Telok. B., Sumatra	0	5 26 S	105 16 E	3	89·68	do.
183	Benkoelen, Sumatra	0	3 47 S	102 14 E	3	124·41	do.
184	Padang, Sumatra	0	0 58 S	100 25 E	3	182·24	do.
185	Loeboeselassi, Sum.	1017	0 57 S	100 38 E	2	150·28	do.
186	Solok, Sumatra	1234	0 48 S	100 40 E	3	90·32	do.
187	Padang P., Sumatra	2560	0 30 S	100 30 E	2	211·14	do.
188	Fort de Kock, Sum.	3041	0 21 S	100 28 E	3	81·22	do.
189	Pajakombo, Sumatra	1630	0 15 S	100 47 E	3	86·42	do.
190	Rau, Sumatra	977	0 32 N	100 3 E	2	87·88	do.
191	Padang S., Sumatra	929	1 23 N	99 15 E	2	107·21	do.
192	Siboga, Sumatra	0	1 44 N	98 46 E	3	187·87	do.
193	Singkel, Sumatra	0	2 17 N	97 45 E	3	180·62	do.
194	Kotta Radja, Sumatra	0	5 32 N	95 20 E	3	69·18	do.
195	Edi, Sumatra	0	5 53 N	97 46 E	2	83·19	do.
196	Agnieta P., Sumatra	--	4 9 N	98 9 E	2	100·08	do.
197	Koeala, S., Sumatra	--	4 18 N	98 3 E	2	99·41	do.
198	Medan, Sumatra	46	3 35 N	98 41 E	2	95·20	do.
199	Medan P., Sumatra	46	3 35 N	98 41 E	3	87·96	do.
200	Sipoet. Sumatra	--	3 30 N	98 38 E	2	122·44	do.
201	Bengkalis, Sumatra	0	1 28 N	102 6 E	2	105·32	do.
202	Djambi, Sumatra	--	1 35 S	103 36 E	3	102·09	do.
203	Palembang, Sumatra	--	2 59 S	104 45 E	3	120·16	do.
204	Tebing T., Sumatra	--	3 36 S	103 4 E	2	126·07	do.
205	Bandar, Sumatra	--	4 5 S	103 22 E	2	125·51	do.
206	Lahat, Sumatra	--	3 48 S	103 31 E	2	151·02	do.
207	Tandjong P., Riouw	0	0 56 N	104 25 E	3	105·79	do.
208	Muntok, Bangka	0	2 3 S	105 9 E	3	132·64	do.
209	Tandjong P., Billiton	0	2 45 S	107 33 E	3	129·84	do.
210	Singkawang, Borneo	0	0 55 N	108 59 E	2	111·56	do.
211	Pontianak, Borneo	--	0 1 N	109 20 E	3	121·58	do.
212	Sintang, Borneo	--	0 7 N	111 32 E	2	147·01	do.
213	Bandjermasin, Bor.	--	3 19 S	114 35 E	3	97·99	do.
214	Pengaron, Borneo	--	3 15 S	115 15 E	2	102·92	do.
215	Amoenthai, Borneo	--	2 15 S	115 10 E	2	97·52	do.
216	Barabei, Borneo	--	2 17 S	115 16 E	2	115·16	do.
217	Makassar, Celebes	0	5 8 S	119 24 E	3	131·81	do.
218	Pangkadjene, Celeb.	0	4 51 S	119 32 E	2	154·29	do.
219	Balang N., Celebes	0	5 7 S	120 14 E	2	101·42	do.
220	Menado, Celebes	13	1 30 N	124 50 E	2	98·86	do.
221	Ternate Island	10	0 47 N	127 22 E	2	93·51	do.
222	Amboina Island	0	3 42 S	128 10 E	3	165·44	do.
223	Banda Island	0	4 32 S	129 53 E	3	117·92	do.
224	Timor K. Island	49	10 10 S	123 34 E	2	52·36	do.
225	Kuka, Cen. Africa	--	13 10 N	14 30 E	--	33·00	Guyot's Phy. Atl.
226	Christiansb'g, W. Af.	--	5 24 N	0 10 W	--	144·00	do.
227	Gabun, W. Africa	287	0 25 N	9 35 E	4	94·17	Zeitsch., xvi–xvii.
228	Chinchoxo, W. Africa	39	5 9 S	12 3 E	2	42·41	A. v Danckelman.

Mean Annual Rain-fall for various Stations.

No.	Station.	Elev. feet.	Lat.	Long.	Years. Obs.	Rain. Inches.	Authority.
229	Palmerston, S. Aust.	70	12° 26′ S	130° 52′ E	10	63·69	Todd's Met. Obs.
230	Southport, S. Aust.	..	12 44 S	131 0 E	4	72·18	do.
231	Yam Creek, S. Aust.	..	13 29 S	131 35 E	4	54·43	do.
232	Pt. Macquarie, N.S.W.	..	31 25 S	152 54 E	16	63·75	Russ. Met. Obs.
233	Kurraj. Hts., N.S.W.	..	33 33 S	150 45 E	13	53·90	do.
234	Sydney, N.S.W.	..	33 51 S	151 12 E	22	51·46	do.
235	Botany, N.S.W.	..	33 56 S	151 12 E	11	53·30	do.
236	Cordeaux R., N.S.W.	..	34 19 S	150 44 E	9	59·89	do.
237	Cape St. Geo., N.S.W.	..	35 12 S	150 45 E	14	56·12	do.
238	Milton, N.S.W.	..	35 14 S	150 20 E	4	50·52	do.
239	Pine Creek, S. Aust.	..	13 52 S	131 56 E	4	46·38	Todd's Met. Obs.
240	R. Katherine, S. Aust.	.	14 23 S	132 17 E	4	43·91	do.
241	Daly Waters, S. Aust.	..	16 17 S	133 29 E	4	31·66	do.
242	Melrose, S. Aust.	..	32 46 S	138 8 E	12	26·82	do.
243	Pewsey Vale, S. Aus.	..	34 36 S	138 58 E	4	28·40	do.
244	Mt. Pleasant, S. Aust.	..	34 46 S	139 3 E	4	27·62	do.
245	Gummeracha, S. Aus.	..	34 47 S	138 55 E	11	32·94	do.
246	Charleston, S. Aust.	..	34 58 S	138 51 E	15	32·99	do.
247	Mt. Lofty, S. Aust.	..	35 0 S	138 43 E	21	42·37	do.
248	Mt. Barker, S. Aust.	..	35 4 S	138 51 E	19	29·59	do.
249	Willunga, S. Aust.	..	35 16 S	138 31 E	18	26·66	do.
250	Yankalilla, S. Aust.	..	35 25 S	138 19 E	12	27·12	do.
251	Penola, S. Aust.	..	37 21 S	140 50 E	19	28·25	do.
252	Mt. Gambier, S. Aus.	130	37 46 S	140 46 E	19	31·80	do.
253	C. N'thumberl'd, S.A.	117	38 4 S	140 39 E	13	28·03	do.
254	Maryland, N.S.W.	..	28 36 S	152 5 E	11	34·80	Russ. Met. Obs.
255	Tenterfield, N.S.W.	..	29 5 S	152 4 E	10	31·07	do.
256	Grafton, N.S.W.	..	29 43 S	152 56 E	10	36·90	do.
257	Armidale, N.S.W.	..	30 34 S	151 46 E	16	35·62	do.
258	Mudgee, N.S.W.	..	32 35 S	149 35 E	9	26·74	do.
259	W. Maitland, N.S.W.	..	32 47 S	151 35 E	12	35·37	do.
260	Newcastle, N.S.W.	..	32 55 S	151 50 E	19	47·64	do.
261	Orange, N.S.W.	..	33 18 S	149 9 E	10	39·18	do.
262	Mt. Victoria, N.S.W.	..	33 36 S	150 15 E	8	37·47	do.
263	Windsor, N.S.W.	..	33 36 S	150 49 E	18	33·61	do.
264	Young, N.S.W.	..	34 18 S	148 21 E	8	28·66	do.
265	Mossvale, N.S.W.	..	34 32 S	150 23 E	8	45·45	do.
266	Goulburn, N.S.W.	..	34 45 S	149 45 E	17	26·79	do.
267	Albury, N.S.W.	..	36 6 S	147 0 E	17	28·03	do.
268	Eden, N.S.W.	..	37 0 S	149 59 E	12	39·29	do.
269	Kooringa, S. Aust.	..	33 42 S	138 59 E	21	17·45	Todd's Met. Obs.
270	Bungaree, S. Aust.	..	33 44 S	138 31 E	20	21·61	do.
271	Clare, S. Aust.	..	33 50 S	138 37 E	18	24·93	do.
272	Auburn, S. Aust.	..	34 2 S	138 38 E	15	24·50	do.
273	Wallaroo, S. Aust.	..	33 54 S	137 38 E	15	13·59	do.
274	Kapunda, S. Aust.	..	34 20 S	139 0 E	19	20·25	do.
275	Gawler, S. Aust.	..	34 35 S	138 45 E	18	18·97	do.
276	Adelaide, S. Aust.	..	34 57 S	138 35 E	41	21·31	do.
277	Strathalbyn, S. Aust.	..	35 16 S	138 55 E	19	18·84	do.
278	Goolwa, S. Aust.	..	35 29 S	138 47 E	16	17·21	do.
279	Meningie, S. Aust.	..	35 41 S	139 19 E	15	19·27	do.
280	Robe, S. Aust.	..	37 3 S	139 42 E	19	24·69	do.
281	Bourke, N.S.W.	..	30 3 S	145 58 E	8	15·45	Russ. Met. Obs.
282	Narrabri, N.S.W.	..	30 20 S	149 46 E	11	24·45	do.
283	Wilcannia, N.S.W.	..	31 31 S	143 23 E	8	11·09	do.
284	Cassilis, N.S.W.	..	32 0 S	150 0 E	10	23·72	do.
285	Scone, N.S.W.	..	32 4 S	150 53 E	7	22·27	do.

Mean Annual Rain-fall for various Stations.

No.	Station.	Elev. feet.	Lat.	Long.	Years Obs.	Rain. Inches.	Authority.
286	Muswellbr'k, N.S.W.	..	32° 17' S	150° 53' E	7	19·00	Russ. Met. Obs.
287	Dubbo, N.S.W.	..	32 18 S	148 35 E	9	20·39	do.
288	Bathurst, N.S.W.	..	33 24 S	149 37 E	19	24·62	do.
289	Wentworth, N.S.W.	..	34 8 S	142 0 E	10	11·55	do.
290	Waggawagga, N.S.W	..	35 8 S	147 24 E	7	23·89	do.
291	Murray Downs, "	..	35 16 S	143 41 E	16	15·59	do.
292	Queanbeyan, N.S.W.	..	35 20 S	149 15 E	10	23·91	do.
293	Deniliguin, N.S.W.	..	35 32 S	145 2 E	20	16·50	do.
294	Cooma, N.S.W.	..	36 12 S	149 9 E	16	19·09	do.
295	Charl. Waters, S. Au.	..	25 50 S	134 57 E	4	8·83	Todd's Met. Obs.
296	Peake, S. Aust.	..	28 4 S	135 50 E	4	7·00	do.
297	Strangw. Spr., S. A.	..	29 11 S	136 33 E	4	6·12	do.
298	Stuart's Creek, S. A.	..	29 45 S	137 5 E	3	8·17	do.
299	Farina, S. Aust.	..	30 4 S	138 14 E	1	6·59	do.
300	Arrowie, S. Aust.	..	30 53 S	139 19 E	3	7·49	do.
301	Beltana, S. Aust.	..	30 58 S	138 27 E	4	8·32	do.
302	Wirrialpa, S. Aust.	..	31 1 S	138 52 E	4	6·94	do.
303	Wintabatingana, "	..	31 20 S	138 18 E	1	8·60	do.
304	Moonaree, S. Aust.	..	31 54 S	135 34 E	2	9·44	do.
305	Port Augusta, S. A.	..	32 29 S	137 45 E	20	8·70	do.
306	Moorna, S. Aust.	..	34 9 S	141 42 E	3	7·87	do.
307	Paringa, S. Aust.	..	34 10 S	140 44 E	7	9·94	do.
308	Goorimpa, N.S.W.	..	30 22 S	144 1 E	2	9·34	Russ. Met. Obs.
309	Tarella, N.S.W.	..	30 55 S	143 0 E	4	9·67	do.
310	Weinteriga, N.S.W.	..	32 8 S	142 52 E	4	9·26	do.
311	Teryawynia, N.S.W.	..	32 20 S	143 20 E	4	9·99	do.
312	Netley, N.S.W.	..	32 53 S	142 20 E	4	9·04	do.
313	Geraldton, W. Aust.	..	28 44 S	114 44 E	2	16·90	Fraser's Met. Ob.
314	Newcastle, W. Aust.	..	31 38 S	116 33 E	2	16·70	do.
315	Northam, W. Aust.	.	31 41 S	116 45 E	2	11·30	do.
316	York, W. Aust.	..	31 52 S	116 47 E	2	16·15	do.
317	Guildford, W. Aust.	..	31 55 S	115 56 E	2	38·25	do.
318	Perth, W. Aust.	..	31 57 S	115 52 E	4	32·58	do.
319	Freemantle, W. Aus.	..	32 2 S	115 42 E	2	26·45	do.
320	Pinjarra, W. Aust.	..	32 34 S	115 52 E	2	35·55	do.
321	Banburg, W. Aust.	..	33 18 S	115 32 E	2	41·90	do.
322	Vasse, W. Aust.	..	33 32 S	115 28 E	2	27·75	do.
323	Albany, W. Aust.	..	35 0 S	117 53 E	2	35·55	do.

servations from the interior of South America is very small, they seem to indicate that (with a few exceptions of limited extent) the entire central and northern portions of South America, east of the Andes, have a rain-fall exceeding 50 inches. The observations from Iquitos and San Antonio indicate a rain-fall of more than 75 inches for the eastern slope of the Andes; but many more observations are needed before the limits of the rain-fall of 50 inches and 75 inches can be satisfactorily assigned. In Europe the principal change is in Norway, the area of 25 inches rain-fall having been made too great on my former chart. In Central Asia I have made considerable change in the curve of 10 inches rain-fall, but this curve is one which it is specially difficult to trace satisfactorily, partly on account of the scarcity

of observations, but especially because there are very extensive regions where the rain-fall does not much exceed 10 inches. Some change has been made in the East Indian Archipelago required by the three years' observations of Dr. Bergsma. The changes in Central Australia are explained by the fact that when I prepared my former chart, the observations which were available were few in number and most of them included a period of only one year. The observations since received appear to indicate that throughout the whole interior of Australia, the average annual rain-fall is less than 10 inches. In Central Africa the present chart shows a greater rain-fall than the former one. Some of the changes are based upon new observations, and others have been made in deference to the judgment of my critics.

It is hoped that this revised rain-chart may be found less imperfect than the preceding. I do not expect, however, that it will be found perfect, and I urgently renew the request contained in my former paper that if any person whose attention is attracted to this map should discover in it serious defects, he will communicate to me the observations which indicate these defects. I propose hereafter to publish all additional observations of rain-fall which I may be able to obtain, so far as they indicate the necessity of changes in the present rain-chart, and if this chart should be found greatly in error, I intend to issue a revised edition of it.

Relation of rain-areas to areas of low pressure.

In former papers I have examined the cases in which a rain-fall of two inches in eight hours has occurred at any of the stations of the U. S. Signal Service, and also the cases in which the aggregate rain-fall at all the stations was unusually great. This examination has shown a marked difference between the effect of a great rain-fall in the northern and southern portions of the United States. South of the parallel of 36° we find that a rain-fall of two inches in eight hours occurs four times as frequently as it does north of that parallel, allowance being made for the difference in the number of stations. Also south of 36° these great rain-falls are not generally accompanied by any considerable depression of the barometer; but there is a cyclonic movement of the winds about the rain-area, accompanied by a small depression of the barometer. In a few cases the barometer stands above its mean height; the cyclonic motion of the winds is not distinctly marked, and the winds seem to be controlled by an area of high pressure prevailing north of 36°.

In the northern portion of the United States, great rain-falls appear to be always under the influence of an area of low pressure. The average distance of the principal rain-centers from

the center of low pressure is nearly 400 miles; they are generally on the east side of the low center, and are most frequently found nearly in the direction of the average progress of storm tracks. There is, then, an intimate connection between the rain-fall and the direction of a storm's progress; and the precipitation of the vapor of the air is apparently the chief source of that maintaining power which is necessary to sustain the action of violent storms. The direction of movement and rate of progress of an area of low pressure do not, however, depend simply upon the amount of rain-fall and position of the rain-areas within the limits of the area of low pressure, but also upon the existing distribution of pressure, temperature and humidity not only within the limits of the storm, but throughout an extensive region surrounding it on all sides.

In order to prosecute this enquiry under different geographical influences, I have prepared tables showing for a series of years the principal rain-falls in Europe. I selected from the Bulletin of International Meteorological Observations all those cases in which a rain-fall of two inches in twenty-four hours was reported at any station during the years 1878, 9 and 80. These cases are 233 in number, and the stations at which more than three cases of these great rain-falls occurred are shown in the following table. Column 2d shows the latitude of the station;

Station.	Lat.	Elev'n feet.	No. of Cases.	Station.	Lat.	Elev'n feet.	No. of Cases.
Trieste	45° 39′	85	26	Puy de Dome	45° 46′	4813	6
Udine	46 4	380	13	Moncalieri	44 59	853	6
Rochefort	45 56	30	12	Pola	44 51	105	6
Genoa	44 25	157	12	Com. de Greasque	43 25	1056	6
Valona	40 27	----	12	Mondovi	44 22	1824	5
Pic du Midi	42 16	7763	11	Carcassonne	43 13	384	5
Santiago	42 53	863	9	Bergen	60 24	49	4

column 3d its elevation in feet above the sea, and column 4th the number of cases in which a rain-fall of two inches in twenty-four hours was reported, at the station named.

The twelve cases of heavy rain reported at Rochefort are believed to be erroneous. They all occurred in the six months from June to November, 1880, and the error is supposed to have resulted from the fact that the rain-fall was measured in tenths of a millimeter, but was reported in such a way that the numbers were understood to represent millimeters, thus making the rain-fall ten times too great. Of the other thirteen stations, all but one are in the south of Europe, and show unequivocally the influence of local causes; two of the stations being on mountains and the others being in the neighborhood of mountains where the mean annual rain-fall is unusually great.

The following table contains a complete list of the cases for 1879. Column 1st gives the number of reference; column 2d, the date of observation; column 3d, the station of heavy rain-fall; column 4th, its latitude; column 5th, its longitude from Greenwich; column 6th, its elevation (in English feet) above sea level; column 7th, the rain-fall in twenty-four hours expressed in English inches; column 8th, the height of the barometer, reduced to sea level; column 10th, the direction of the wind at the date of observation; column 9th, its direction twenty-four hours previous; and column 11th, shows the direction of the given station from the center of low pressure with which it is believed to have been associated.

The average height of the barometer at the time of these heavy rains was 29·8 inches, and in only twenty-six cases was the barometer below 29·75 inches. In eleven cases the barometer at the station of greatest rain was above 30 inches; but in eight of these eleven cases, although the barometer was above its mean height, it was from three-tenths to seven-tenths of an inch lower than it was in some other part of Europe. Also in eight of these cases, there was a low center within a distance of about 1000 miles where the barometer was from a half inch to an entire inch lower than it was at the station of 2 inches rain-fall. Most of these eleven cases were therefore cases in which the influence of a low center was felt to an unusual distance. There were however two cases (Nos. 54 and 57) both on the same day, in which there was no considerable low center within a distance of 1000 miles, and these occurred in a region where a cyclonic movement of the winds of limited extent was formed between two centers of high pressure. We thus find that each of these cases of heavy rain occurred within an area where the barometer was depressed somewhat below its mean height, or where the barometer was relatively low when compared with neighboring areas of high pressure.

Within these areas of low pressure there was generally a cyclonic movement of the winds. This is indicated by the change in the direction of the winds shown in columns 9th and 10th. It will be seen that in eight cases the wind changed 180° in twenty-four hours; in seventeen cases the wind changed 135° in twenty-four hours; and in twenty-eight cases the wind changed 90° in twenty-four hours. There are, however, twelve cases in which no change in the direction of the wind was reported during these twenty-four hours, viz: Nos. 2, 4, 5, 8, 18, 20, 41, 60, 64, 66, 68 and 73. In eight of these cases the low center traveled very slowly, and the direction of the low center from the rain center changed but little in twenty-four hours; two of the remaining cases occurred on the summit of a mountain about which there is presumed to have been

Rain-fall of two inches in 24 hours.

No.	Date.	Station.	Lat.	Long. fr. Green.	Elev. feet.	Rain. inch's	Bar. red'd.	Wind. Prev. observ.	Wind. At date.	From low.
	1879.		° ′	° ′						
1	Jan. 2	Trieste, Austria	45 39	13 47 E	85	2·334	29·82	Calm	Calm	SE
2	4	Carlsruhe, Germ.	49 1	8 25 E	404	2·181	29 61	SW	SW	SW
3	6	Pic du Midi, France	42 16	0 8 E	7763	2·240	30·22	NNW	N	?
4	7	Pic du Midi, France	42 16	0 8 E	7763	2·212	30·07	N	N	?
5	10	Valona, Turkey	40 27	19 27 E	--	3·940	29·76	S	S	SE
6	30	Trieste, Austria	45 39	13 47 E	85	2·035	30·09	E	ENE	NE
7	Feb. 1	Nottingham, Eng.	52 57	1 10 W	174	2·770	30·08	ESE	SE	NE
8	9	Santiago, Spain	42 53	8 28 W	863	3·048	29 51	S	S	SE
9	10	Santiago, Spain	42 53	8 28 W	863	2·713	29·38	S	SW	SE
10	15	Trieste. Austria	45 39	13 47 E	85	2·063	29·51	Calm	E	NE
11	15	Monach, Hebrides	57 30	7 40 W	150	2·000	29·21	E	SSE	SE
12	15	Genoa, Italy	44 25	8 30 E	157	2·587	29·46	Calm	N	NE
13	17	Mont Louis, France	42 31	2 7 E	5203	2·917	29·71	SSW	WSW	S
14	Mar. 22	Genoa, Italy	44 25	8 30 E	157	2·657	29·58	Calm	S	E
15	23	Trieste, Austria	45 39	13 47 E	85	2·976	29·53	E	Calm	NE
16	26	Trieste, Austria	45 39	13 47 E	85	2·028	29·83	ENE	S	E
17	27	Trieste, Austria	45 39	13 47 E	85	3·511	29·63	S	E	SE
18	Apr. 3	Pic du Midi, France	42 16	0 8 E	7763	2·390	29·82	NW	NW	?
19	4	Pic du Midi, France	42 16	0 8 E	7763	2·469	29 95	NW	N	?
20	8	Nice, France	43 42	7 17 E	30	2·110	29·47	S	S	SE
21	8	Commune de Gr.	43 25	5 37 E	1056	2·252	29·47	SE	N	SE
22	16	Trieste, Austria	45 39	13 47 E	85	2·063	29·69	S	N	NE
23	21	Genoa, Italy	44 25	8 30 E	157	3·346	29·55	SW	NE	SE
24	22	Udine, Italy	46 4	13 14 E	380	2·252	29 70	S	SE	SE
25	29	Rome, Italy	41 54	12 29 E	207	2·598	29.69	W	N	SE
26	May 10	Puy de Dome, Fr.	45 46	2 58 E	4813	3·906	29·84	NW	NNW	SW
27	11	Cracow, Austria	50 4	20 0 E	721	2·467	29·68	ESE	NW	NW
28	20	Mondovi, Italy	44 22	7 48 E	1824	2·468	29·98	NNW	W	N
29	24	Moncalieri, Italy	44 59	7 41 E	853	2·098	29·91	SE	N	NE
30	26	Mondovi, Italy	44 22	7 48 E	1824	3·378	29·72	W	WNW	N
31	27	Mondovi, Italy	44 22	7 48 E	1824	2·091	29·69	WNW	N	SE
32	28	Szathmar, Austria	47 49	22 51 E	430	2·059	29·88	E	SW	SE
33	June 8	Santiago, Spain	42 53	8 28 W	863	2·241	29·82	SSW	W	SE
34	10	Eperies, Austria	48 58	21 15 E	820	2·045	29·90	SE	NW	SW
35	18	Hamburg, Germ.	53 33	9 58 E	66	3·366	29·62	SW	S	SE
36	July 2	Besançon, France	47 14	6 1 E	830	2·067	29·97	SW	SSW	SE
37	14	Nismes, France	43 51	4 21 E	187	2·760	29·95	S	N	SE
38	14	Geneva, Switz.	46 12	6 8 E	1339	2·551	29·90	NE	SW	SE
39	Aug. 3	Cambridge, Eng.	52 12	0 8 E	88	3·180	29·86	E	SE	NE
40	3	Cardington, Eng.	52 8	0 27 W	109	2·000	29·84	E	SE	NE
41	10	Besançon, France	47 14	6 1 E	830	2·421	30·08	S	S	?
42	17	Trieste. Austria	45 39	13 47 E	85	2·020	29·89	ESE	E	SE
43	17	Barcelona, Spain	41 23	2 11 E	98	2·908	29·99	SE	SSW	NE
44	18	Gratz, Austria	47 4	15 28 E	1171	3·544	29·86	NE	SE	SE
45	18	Hermannstadt, Aus	45 47	24 13 E	1355	2·150	29·71	WNW	WNW	SE
46	Sept. 2	Bergen, Norway	60 24	5 18 E	49	2·401	29 72	NW	S	NE
47	9	Christiania, Nor.	59 55	10 44 E	134	2·043	29·50	ENE	SSW	NE
48	10	Umea. Sweden	63 50	20 17 E	--	2·389	29·42	SE	N	NE
49	15	Carcassonne, Fr.	43 13	2 21 E	384	2·217	29·90	E	W	S
50	15	Commune de Gr.	43 25	5 37 E	1056	2 170	29·96	SW	SE	SE
51	15	Marseilles, France	43 18	5 23 E	246	3·051	29·88	SE	E	SE
52	16	Marseilles, France	43 18	5 23 E	246	6·261	29·91	E	ESE	SE
53	18	Pola, Austria	44 51	13 53 E	105	2·028	29·97	ESE	WNW	SE
54	25	Avignon, France	43 57	4 38 E	66	5·836	30 09	E	N	NW
55	25	Milan. Italy	45 28	9 11 E	482	2·599	29·99	NE	E	NE
56	25	Christiania, Nor.	59 55	10 44 E	134	3·083	29·86	SSE	SSW	SE
57	25	Zurich, Switz.	47 22	8 33 E	1542	2·047	30·21	S	W	NE

Rain-fall of two inches in 24 hours—continued.

No.	Date.	Station.	Lat.	Long. fr. Green.	Elev. feet.	Rain. inch's	Bar. red'd.	Wind. Prev. observ.	Wind. At date.	From low.
	1879.		° ′	° ′						
58	Sep. 26	Pola, Austria	44 51	13 53 E	105	3·962	29·85	SSE	WSW	NE
59	28	Nice, France	43 42	7 17 E	30	2·322	30·07	E	ESE	NW
60	Oct. 1	Santiago, Spain	42 53	8 28 W	863	2·091	30·03	SW	SW	SE
61	16	Brōno, Norway	65 30	12 0 E	36	2·087	29·80	NE	SW	NE
62	17	Cosenza, Italy	39 18	16 15 E	840	2·197	29·78	SE	NW	SW
63	18	Pola, Austria	44 51	13 53 E	105	2·008	29·85	WNW	SSW	SE
64	21	Carlsruhe, Germ.	49 1	8 25 E	404	2·020	29·79	SW	SW	SW
65	23	Valona, Turkey	40 27	19 27 E	..	2·360	29·88	SE	N	SW
66	28	San Fernando, Sp.	36 28	6 13 W	95	2·134	29·81	S	S	SE
67	29	Carcassonne, Fr.	43 13	2 21 E	384	2·106	29·85	ESE	E	NE
68	29	Perpignan, Fr.	42 42	2 54 E	98	2·102	29·86	SE	SE	NE
69	29	San Fernando, Sp.	36 28	6 13 W	95	3·183	29·78	S	SE	S
70	Nov. 1	Campo Major, Por.	39 2	6 59 W	945	2·296	29·79	ESE	SSW	E
71	2	Genoa, Italy	44 25	8 30 E	157	2·126	29·80	SW	S	NE
72	20	Genoa, Italy	44 25	8 30 E	157	3·165	29·88	NW	NE	NE
73	25	Helston, Eng.	50 5	5 17 W	..	2·400	30·32	E	E	NE
74	28	Santiago, Spain	42 53	8 28 W	863	2·024	29·30	NE	SSE	N
75	Dec. 4	Genoa, Italy	44 25	8 30 E	157	2·539	29·53	NE	N	SE
76	15	Bergen, Norway	60 24	5 18 E	49	2·500	30·29	SSE	SE	SE

a cyclonic movement of the winds nearly stationary as will be shown hereafter. In No. 2 there was a small barometric depression about 200 miles distant on the north side, and about this center there was a decided cyclonic movement of the winds. It seems probable that there was some change of wind at Carlsruhe during this period of twenty-four hours. In No. 41 the winds in France were light and a cyclonic movement of the winds was formed near Besançon resulting in a great rainfall, but without any appreciable effect upon the barometer. We therefore conclude that each of these cases of great rainfall (with perhaps one or two exceptions) occurred within an area of pressure somewhat below the mean, or at least a pressure relatively low, and that there was a cyclonic movement of the winds about this low center.

In order to show the position of these heavy rain-falls with respect to the centers of low pressure, I have prepared a chart of all these cases for 1879 similar to Plate I, which accompanied my seventeenth paper. Column 11th of the preceding table shows the quadrant in which each of these rain centers was situated, except that in a few cases the direction corresponded very nearly with one of the cardinal points, and this is indicated by the letters N, E, or S. There are also five cases marked with the character ? which will be considered hereafter. The following is a summary of the number of cases of great rain-falls for each of the four quadrants about the center of low pressure:

Northeast.	Southeast.	Southwest.	Northwest.
22	31	6	3

The three cases in which the great rain-fall took place on the N.W. side of the low center are Nos. 27, 54 and 59. May 11th there was a low center (29·37) about 200 miles southeast of Cracow, and during the preceding twenty-four hours the low center traveled only 275 miles, which is considerably less than the average velocity in this part of Europe for the month of May. Sept. 25th there was a high barometer (30·58) at Moscow, and another high (30·39) over Spain. Under the influence of these two areas of high pressure, a system of cyclonic winds was formed about the southeast part of France, resulting in a heavy rain-fall at various places in Switzerland and Northern Italy as well as at Avignon. This movement of the winds caused a considerable depression of the barometer (29·83) which was central over Northern Italy on Sept. 26th. Although the heaviest rain-fall may have occurred on the northwest side of this low center, very heavy rain also occurred on the northeast side of the low center. Sept. 28th there was a low center (29·80) southeast of Nice, and distant about 500 miles. During the preceding forty-eight hours, this low center traveled only 400 miles, or about eight miles per hour. Cases No. 27 and 59 appear to have been similar to that of Aug. 12, 1880, in Austria, where the principal rain-fall was on the west side of the low center and the low center remained nearly stationary for several days. It seems natural to conclude that the low center remained stationary *because* the principal rain-fall was on its west side.

The six cases in which the great rain-fall took place on the S.W. side of the low center are Nos. 2, 26, 34, 62, 64 and 65. Jan. 4th Carlsruhe was situated on the S.W. side of a low center (29·13 inches) at a distance of nearly 1000 miles; but on the 3d of January there was a decided cyclonic movement of the winds about the southern portion of the North Sea, accompanied by a slight depression of the barometer on the northwestern side of Carlsruhe, and the great rain-fall at Carlsruhe was probably the result of this local movement rather than the effect of that distant area of low pressure on the northeast side. No. 26, May 10th, was similar to the preceding case. A cyclonic movement of the winds covering nearly the whole of France was very decided, although the principal center of low pressure was distant 800 miles on the east side. No. 34, June 10th, was also similar to the preceding, the wind at Eperies having been S.E. June 9th and N.W. June 10th. No. 62, Oct. 17th, presents another similar case. The wind at Cosenza was S.E. on the 16th and N.W. on the 17th. In No. 64, Oct. 21st, rain was very general throughout nearly the whole of Europe, and it apparently resulted not so much from the existence of an area of low pressure over the Baltic Sea,

as from local cyclonic winds prevailing over Northern Italy and Austria, although the observations do not show any such system of winds near Carlsruhe. In these five cases the great rain-fall occurred at a distance of from 600 to 800 miles from the center of the low area in which it was included. In my seventeenth paper I have shown that in the United States, when a heavy rain-fall occurs at a distance of more than 500 miles south of a low center, the rain fall has apparently very little influence upon the direction in which the low center advances, or upon its rate of progress. A similar remark is applicable to Europe. In these five cases the rain-fall appeared to have very little influence upon the center of the principal low area in which the rain center was situated; but in four of the cases a subordinate low center was formed near the rain area. In the other case (No. 34) the local effect uopn the barometer was not distinctly marked. In No. 65, Oct. 23d, the low center was about 100 miles N.E. of Valona. On the 22d the wind was S.E. and 1·30 inch of rain was reported; on the 23d the wind was north and 2·36 inches of rain were reported. The observations do not clearly show whether this rain fell chiefly before or after the change of wind.

Of the five cases in the table which are marked with an ? in column 11th, four occurred on the Pic du Midi. In each of these cases there were indications of a cyclonic movement of the winds around the Pyrenees. This is seen by comparing the direction of the winds at the nearest stations of observation on different sides of the mountains. The following table shows the four cases of 1879 and also all the cases in 1878 and 1880, in which the precipitation at this place amounted to two inches of water in twenty-four hours.

No.	Date.	Bilbao.	Tarbes.	Pic du Midi.	Toulouse.	Mont Louis.	Carcassonne.	Perpignan.	Barcelona.
1	1879. Jan. 6	NW	W	N	NW	NW	NW	NE	E
2	Jan. 7	NW	SSW	N	W	WNW	NE	E	E
3	April 3	NW	W	NW	W	W	W	NE	SE
4	April 4	NW	W	N	NW	NW	W	N	S
5	1878. Mar. 25	NW	WSW	NW	WNW	WSW	W	NW	NE
6	Dec. 2	NW	..	NNE	WNW	SW	E	N	WNW
7	1880. April 3	SW	NW	S	W	WSW	W	NE	S
8	April 27	NW	W	NNE	N	WNW	WNW	NW	E
9	May 6	NW	W	NE	SE	WNW	E	NW	S
10	May 7	NW	W	W	NNW	W	W	NW	SSW
11	Sept. 20	NW	W	W	NW	WSW	W	NE	SSE

In 1880, the direction of the wind on the Pic du Midi was not reported, and the winds shown for that station in 1880 are the directions of the lower clouds. At Mont Louis the lower clouds were reported from S. in case 1; from S.E. in case

6; from E. in case 8, and from E. in case 10. At Carcassonne the lower clouds were reported from E. in case 2. In most of these cases the evidence of a cyclonic movement of the winds is very distinct. The observations at Barcelona indicate a cyclonic movement about the eastern portion of the Pyrenees in nine of the cases; the observations at Perpignan indicate such a movement in five of the cases; the observations at Carcassonne indicate such a movement in three of the cases; the observations of the clouds at Mont Louis indicate such a movement in four of the cases; and the observations on the Pic du Midi indicate such a movement in four of the cases. For the eleven cases we may conclude that in eight of them the cyclonic motion of the winds is distinctly marked; while in three of them the evidence is not entirely clear. No. 41 occurred where the barometer was near its normal height and was situated between two areas of low pressure. A local circuit was formed near Besançon, resulting in a great rain-fall, but without any appreciable effect upon the barometer.

Cyclonic movement of the winds about Trieste.

No.	Date.	Moncalieri.	Mondovi.	Milan.	Florence.	Padua.	Pesaro.	Udine.	Trieste.	Pola.	Gratz.	Agram.	Kremsmunster.
	1879.												
1	Jan. 2	ESE	NE	W	SW	NW	S	Calm	Calm	S	WNW	NW	WNW
2	30	ENE	NW	SSE	W	NE	N	SE	ENE	ENE	SSE	E	ENE
3	Feb. 15	NNW	WSW	NNE	SE	NE	SE	NE	E	SE	WSW	E	NE
4	Mar. 23	W	NW	SE	E	NE	N	SE	Calm	SE	SW	SE	E
5	26	E	W	ESE	SE	NNE	E	E	S	SE	S	E	ENE
6	27	SSE	NNW	S	NW	NNE	NW	E	E	W	E	E	ENE
7	April 16	ENE	SW	E	E	N	N	SW	N	SE	WSW	SW	NE
8	Aug. 17	WSW	NW	ESE	S	SE	SE	SE	E	S	NE	SW	W
	1878.												
9	April 24	NNW	SW	NE	SE	NNE	E	E	ENE	SE	SW	SE	SE
10	May 8	W	NW	E	WSW	SW	W	S	SW	SSW	NW	SW	W
11	25	SSE	NE	NE	SW	ENE	SE	S	SE	SE	SW	SW	WNW
12	June 5	SSE	N	SW	W	E	SW	SE	Calm	SSE	SSW	NE	W
13	15	SSW	ENE	N	SW	SE	S	SW	E	S	ESE	NE	WSW
14	July 26	SSW	NW	--	WSW	NNE	NE	N	ESE	Calm	E	NW	W
15	30	NE	NE	--	W	SE	E	Calm	NW	SE	NE	NE	W
16	Sept. 15	SW	NW	SE	SE	ENE	W	Calm	Calm	NE	E	NE	Calm
17	20	NW	N	ESE	NW	SE	NE	--	W	SE	SW	NE	Calm
18	24	NNW	NW	E	E	NE	--	E	SSE	SE	S	NE	W
19	Oct. 9	SE	N	E	ENE	E	--	E	Calm	SSE	E	NE	Calm
20	14	SSE	W	W	WNW	ENE	NW	NE	ENE	ENE	ENE	NE	ENE
21	21	NNW	NW	ENE	SE	N	E	Calm	Calm	S	S	SW	ENE
22	Nov. 14	NE	SE	W	SW	S	NW	N	SW	SSE	NE	NE	W
23	Dec. 17	ENE	Calm	NE	N	N	W	NE	Calm	SSE	S	SW	Calm
	1880.												
24	July 31	NNW	WNW	S	S	NNW	NE	SW	N	SE	S	NE	WSW
25	Sept. 20	ENE	NE	ESE	SSE	E	S	SW	SW	SSW	SE	NE	WNW
26	Dec. 18	N	WNW	N	ENE	N	S	SW	Calm	SSE	SSW	E	ESE

In nearly all of the other cases in the table, the evidence of a cyclonic movement of the winds about the rain center is equally clear. In order to give a more distinct idea of the nature of the evidence, I subjoin the preceding table showing the direction of the winds at a few of the stations near Trieste at the time of the rain-fall of two inches at the latter place. The table shows all the cases which occurred at this station during the three years 1878, 1879 and 1880.

In nearly all of these cases the evidence of a cyclonic movement of the winds about a center not far from Trieste is unequivocal. The cases which appear most doubtful are Nos. 1 and 10. In No. 1 we find south winds at Pesaro and Pola opposed by northwest winds at Padua and Agram, which affords pretty good evidence of a cyclonic movement. In the case of No. 10 the low center was on the east side of the stations shown in the table; but at several stations farther east, the winds blew from an eastern quarter.

The preceding discussion appears to me to warrant the following conclusions.

1. Cases of very heavy rain-fall in Europe almost invariably occur within or near an area of low pressure, but a great rain-fall is frequently due to a local cyclone of moderate extent formed within or near a large area of low pressure. This remark applies not merely to those cases in the table in which the rain-center was on the west side of the center of low pressure, but also to many of the cases in which it was on the east side. Whenever the movement of the winds about a center of low pressure is feeble, there frequently results a local disturbance attended by a cyclonic motion of the winds and a considerable precipitation of vapor; and this is generally associated with a subordinate area of low pressure which sometimes extends and attains considerable magnitude. In many cases, this precipitation of vapor appears to be due to the influence of mountains by which the air when set in motion is deflected upward.

2. These rain-falls most frequently occur on the east side of an area of low pressure. In 1879, the cases in which a heavy rain-fall occurred on the east side of a low center, were nearly six times as numerous as those on the west side; and even if we count all those cases marked N or S, as having occurred on the west side of the low center, we shall still find the cases on the east side to be nearly four times as numerous as those on the west side.

3. Nearly four-fifths of the cases enumerated in the table on page 12 occurred at stations south of lat. 48°, so that the conclusions above stated apply primarily to southern Europe, and we cannot fail to notice a marked correspondence between the

effects of a heavy rain-fall in southern Europe, and in the southern part of the United States. In both countries the influence of a great rain-fall upon a center of low pressure is generally not very decidedly marked; while in the northern part of the United States, this influence is generally quite obvious and decided. In the United States, the parallel of 36° generally forms a satisfactory dividing line between these two classes of cases; but in Europe this dividing line is found in a much higher latitude, perhaps near the parallel of 48°. I have made an extensive collection of cases of heavy rain in Europe, north of this parallel, and have found a close correspondence with cases of heavy rain in the United States, north of the parallel of 36°. For the year 1880, in northern Europe (employing all cases in which the rain-fall amounted to as much as one inch in 24 hours), the rain-center occurred on the east side of the center of low pressure more than four times as frequently as it did on the west side; the rain-center was found in the northeast quadrant as frequently as in the southeast quadrant; the cases of one inch rain-fall in the northwest quadrant were only three in number, and in neither of these cases was the rain-center distant from the center of low pressure more than 150 miles. For all the cases in 1880 in northern Europe, the average distance of the rain-center from the center of low pressure was 420 miles, and the average pressure at the center was 740 millimeters or 29·13 inches.

ART. II.—*On Bowlder Drift in Delaware;* by F. D. CHESTER.

ABOUT two miles to the south of Newark, Delaware, on the line of the Baltimore & Philadelphia Railroad, there rise above the level of the plain two hills, which, uniting with each other, trend in a nearly east and west direction. Their total length is about two miles, their breadth one mile, and their height between two and three hundred feet.

These hills present material for interesting geological observations from two principal reasons. In the first place, like most hills of this size they are not made up of rocky strata, but from base to summit the forming material is an irregular mixture of sand, gravel and bowlders. The subject has further interest because this material, which is clearly of true drift origin, is found so far to the south, and below the southern limit, of the glacial field.

From Newark to Wilmington, running across the northern part of Delaware, is a chain of hills made up of the highly tilted gneissic rocks; this chain marks the southern boundary

of the Archæan rocks of the State. Resting unconformably upon these latter are strata of red, white and yellow clays of Cretaceous age, dipping at so low an angle to the southeast, that they seem almost horizontal. The position of these clay deposits gives to the country south of Newark a very even topography, hence when we see these two hills of detritus rising above the plain they become objects peculiarly conspicuous and interesting.

At the very foot of the hills we find the material a ferruginous sand, mixed with quartzose pebbles and fragments of compact iron-stone. Wherever we can get cuttings in this loose earth, no apparent signs of stratification can be observed; on the contrary we see only a confused mixture. As we reach the top we find excellent cuttings made where iron ore is worked in open quarry. The side of the hill near one of these workings has scattered over its surface large bowlders of iron-stone, ferruginous quartz and dolerite. In one of the cuttings the bank rises to a height of thirty feet. The main material is the same red sand and gravel, slightly argillaceous. No signs of stratification can be observed anywhere, but irregularly disseminated throughout the earth are fragments and bowlders of various materials, the most conspicuous being the immense bowlders of iron-stone. Among the other materials noticed in this confused mixture were fragments of green talcose slate, decomposed soapstone, kaolin and bowlders of compact dolerite. One immense slab of light green talcose slate was found embedded in the earth, which upon measurement I found to be fifty feet around.

In another cutting the banks of ferruginous sand and gravel rise between thirty-five and forty feet, with no signs of stratification, but with the materials scattered through the earth in irregular patches, bowlders and fragments. These former, so characteristic of this cutting, are made up of red and white decomposed materials, derived from the decay of a red orthoclase granite in one case and in the other of a black micaceous gneiss. The white patches are by far the largest and most numerous, one of which presented a face thirty feet high, and fifty feet long. Facts clearly point to the belief that the rocks whence the granitic materials came were brought to their present position in a solid state, and that the decomposition was subsequent, for it is found that in the white there is still the distinct schistose structure of the original rock, while the red retains its true granitic characters. The chief interest connected with these facts is that the rocks whence these loose materials came must have been immense in size, as well as numerous, and that they were once scattered through the earth like the equally large bowlders of ferruginous quartz and iron-stone.

Some of these latter are enormous in size. One bowlder of highly ferruginous quartz was found to measure forty-one feet in circumference; another of nearly equal size and of the same material was seen resting like a rocking stone upon a smaller one beneath, the earth having been removed from around it. Besides these larger examples, the whole bank is completely filled with bowlders of iron-stone, large and small, distributed irregularly throughout the confused mass, and it is this fact which gives the deposits their economic importance.

One of the most interesting facts with regard to the geology of these hills is the occurrence of great bowlders of dolerite which are thickly strewn over every part and even in the meadow land to the north, and just at the foot of the hills the ground is so covered with them, that one is immediately reminded of similar scenes in more northern latitudes. At the very beginning of the ascent I came across the largest bowlder of dolerite yet found; it measured thirty-seven feet in circumference, and another near by, sixteen. At the top, the west side of one of the hills was so literally strewn with bowlders that one could not step without walking on them; one of these measured twenty-five feet in circumference and numerous others were not less than fifteen, all the remainder varying from this size down.

I have to note here that I have found bowlders both to the north and ten miles to the south of these hills, some of them varying in size from fifteen to twenty feet in circumference.

In all these cases of bowlder examination, I have not succeeded in discovering distinct glacial scratches, although patient search was kept up. In a few instances parallel striæ were seen, but these were so obscured by the extreme weathering of bowlders that their true nature remains a question of doubt.

In almost every case the surfaces of the rocks were either so weather-worn or moss-covered as to obscure all evidence with regard to this point, and their presence or absence must remain an uncertain question. As to the explanation how bowlder drift could have been brought to this remote locality, there is much which is interesting. It is a well-known fact to all geologists, that bowlders have been found as far south as the Southern States, and that their presence in these localities is explained by supposing that they were transported by floating icebergs which found their way to the south at the close of the Glacial period; hence it seems to be the most probable theory, that not only the solitary bowlders found in Delaware, but that the materials of these two hills were transported southward by floating ice during the Champlain period.

The entire want of stratification observed in both hills would tend to show that the materials were dropped pell-mell from

the melting ice-floats, while the slightly stratified arrangement of the sand and gravel for not more than a foot in the topmost layer of the cuttings would show a slightly modifying effect of the waters into which the debris was dropped. It was only in two localities that this stratification of the surface could be observed, while such regular arrangement was by no means true of all parts of the uppermost material.

Professor G. H. Cook (Ann. Rept. of N. J., 1880, p. 94) mentions the occurrence of bowlders in Cape May County, New Jersey, near the town of Dennisville. He gives the dimensions of the largest one found in that part of the State as fourteen feet, and its other dimensions eleven to seventeen inches, by thirteen to sixteen inches. These figures may make some readers skeptical as to those already given, yet their accuracy may in this case be depended upon, since the bowlders were accurately measured by myself.

Professor Cook attributes the presence of bowlders in Cape May County to ice-flows coming down the Delaware, when the land was submerged to the depth of at least sixty feet during the Champlain period.

It is hardly probable that Professor Cook's explanation will apply to the case of the two hills or the bowlders of Delaware, from the fact that the base of these hills is not less than eighty feet above the Delaware river, and, adding to this 228 feet, the height of one of the hills, and considering the further fact that a few of the largest bowlders are found at the very summit, we have the occurrence of these rocks 308 feet above the level of the river. There is again the further consideration that while the bowlders about Dennisville occur upon the alluvial land bordering the Delaware, and upon land no doubt the work of this stream, those of Delaware are found from ten to twelve miles from the river, and with different geological surroundings. The tracing also of sand and gravel, similar in character to that found in the hills, for some distance due north, would also seem to indicate that the floating ice was not alone confined to even the ancient channel of the Delaware River.

Whether the great height of these hills above the level of the Delaware would not seem to indicate a greater submergence of the land during the Champlain period than is reckoned for this locality, will be a question worthy of consideration, provided future evidence shall strengthen the theory.

Delaware College, Newark, Delaware, Dec. 8, 1882.

ART. III. — *Upon the Electrical Experiments to determine the location of the Bullet in the body of the late President Garfield: and upon a successful form of Induction Balance for the painless detection of Metallic Masses in the Human Body;** by ALEXANDER GRAHAM BELL.

(A paper read before the American Association for the Advancement of Science, at the Montreal meeting, August, 1882.)

THE subject of my present paper recalls a time of intense excitement and painful suspense. The long, weary struggle with the untimely death-wound—the prolonged suffering borne so bravely and well by the lamented President Garfield—must still be fresh in every recollection. The whole world watched by his bed-side, and hopes and fears filled every passing hour. No one could venture to predict the end so long as the position of the bullet remained unknown. The bullet might become safely encysted, but, on the other hand, recovery might depend upon its extraction. The search with knife and probe among vital and sensitive tissues could not be otherwise than painful and dangerous; and the thought naturally arose that science should be able to discover some less barbarous method of exploration.

Among other ideas the thought occurred that the bullet might produce some sensible effect in modifying the field of induction of a coil brought near the body of the President, and that the locality of the bullet might thus be determined without danger to the patient and without pain; for it is well known that induction can be powerfully exerted through the human body without producing any sensation whatever.

Upon the balancing of Induction.—The influence that is exercised upon induction by metallic masses has formed the subject of numerous experiments by different investigators; and the principle of balancing the effects of induction on one portion of a circuit by equal and opposite effects produced upon another portion has been utilized in nearly all such investigations.

The earliest form of induction balance for this purpose appears to have been devised in Germany by Prof. Dove,† about the year 1841, and a good description of it in the English language may be found in De la Rive's "Treatise on Electricity," (1853 edition, vol. i, pp. 418–433).‡

* A preliminary notice relating to this paper was published in the Comptes Rendus of the French Academy of Sciences, Oct. 24th, 1881.

† Pogg. Ann., vol. liv, pp. 305–335.

‡ A similar apparatus was independently devised in America a number of years ago by Prof. Rowland, of the Johns Hopkins University. It is to be regretted that his discovery of the fact that he had been anticipated by Dove prevented Prof. Rowland from completing and publishing his researches.

Another and superior arrangement for the same purpose is the well-known induction balance of Prof. D. E. Hughes.*

The Static Induction Balance of J. E. H. Gordon † though primarily intended for experiments upon specific inductive capacity, might also, perhaps, be employed in the same class of investigations.

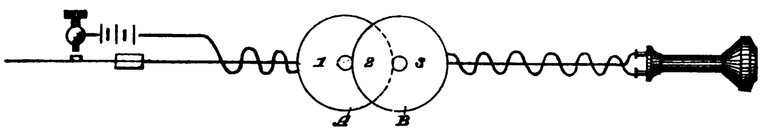
My own attention was directed to the balancing of induction a number of years ago by the disturbing noises produced in the telephone by the operation of telegraphic instruments upon lines running near the telephone conductor.

The difficulty was remedied by using two conductors instead of one, and by so arranging them with reference to the disturbing wires that the currents induced in one of the telephone conductors were exactly equal and opposite to those induced in the other. In this way an induction balance was produced and a quiet circuit secured for telephonic purposes. This method was patented in England in November, 1877, and during the whole winter of 1877-8 I was engaged in London upon experiments relating to the subject.

In the course of these researches I made frequent use of flat spirals of insulated wire, like those employed by the late Prof. Henry‡ in his experiments upon induction.

My method was to pass a rapidly interrupted voltaic current through one flat spiral while I examined its field of induction by means of another flat spiral connected with a telephone. The currents induced in the latter coil produced a musical tone from the telephone.

Fig. 1.



At every point in the field of induction it was found that by turning the plane of the exploring coil a position of silence could be obtained, and another of maximum sound, the two positions making a right angle with one another.

It was also noticed that when a position of silence was established a piece of metal brought within the field of induction caused the telephone to sound. This effect was most marked when the two flat spirals were in close proximity, and were arranged with their planes parallel, as shown in fig. 1.

When a silver coin, such as a half-crown or florin was passed across the face of the two coils, the silence of the telephone was broken three times. The instrument emitted a musical

* Phil. Mag., July, 1879, vol. ii, p. 50. † Phil. Trans. for 1879, p. 417.
‡ This Journal, xxviii, 329; xxxviii, 209; xli, 117.

tone when the metallic disk passed the points marked 1, 2 and 3 in the illustration, but the loudest effect was produced when the coin crossed the area marked "2," where the two coils overlapped.

After my return to America I embodied these and other results in a paper "Upon New Methods of Exploring the Field of Induction of Flat Spirals," which was read before this Association at the Saratoga meeting in August, 1879.

Practical application.—While brooding over the problem of the detection of the bullet in the body of President Garfield, these experiments made in England returned vividly to my mind. It seemed to me that if the overlapping area "2" of the two coils shown in fig. 1 could be brought over the seat of the bullet without disturbing the relative positions of the coils, the telephone would probably announce the presence of the bullet by an audible sound.

A crude experiment was at once made to test the idea. A large, single-pole electro-magnet (the core of which was composed of a bundle of fine iron wires) was used in place of coil A (fig. 1); and a small coil of fine wire taken from a hand telephone was arranged a little to one side of the pole to represent coil B. The small coil being connected with a telephone, a battery current was passed through the coil of the electro-magnet, and the battery circuit was made and broken by an assistant.

Under these circumstances a much better balance was obtained than could possibly have been anticipated. Upon now bringing a leaden bullet near the small coil, a distinct ticking sound could be heard from the telephone each time the battery circuit was made and broken.

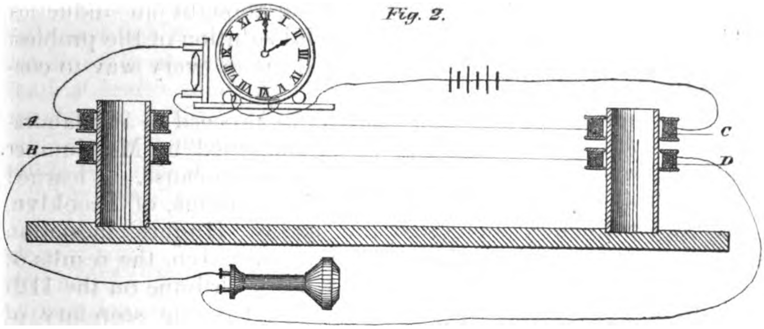
Being absent from my laboratory, and without facilities for proper experiment, I communicated my ideas to Mr. Charles Williams, Jr., of Boston, manufacturer of electrical and telephonic apparatus, who kindly placed the resources of his large establishment at my service; and, at great personal inconvenience, delegated his best workmen to attend to my experiments.

Upon attempting to devise an appropriate form of apparatus for the special purpose in view I saw that there were great practical difficulties in the way of utilizing the arrangement shown in fig. 1, and it occurred to me that the apparatus of Prof. Hughes might perhaps be employed with more advantage as the basis of my experiments. In the ordinary form of Hughes' induction balance four coils are used, as shown in fig. 2. Through the agency of a Hughes microphone the ticking of a clock is made to create an electrical disturbance in the voltaic circuit containing the two primary coils (A C) and a

corresponding disturbance is produced by induction in the two secondary coils (B D) connected with the telephone. If the connections are so arranged that the currents induced in the telephone circuit by the coils A C are in the same direction, the ticking of the clock is heard very plainly, but if they are in opposite directions no sound is perceived.

In the latter case the action of one primary coil (A) opposes that of the other (C), and an electrical balance results. If now a piece of metal is brought near one pair of coils (say A B) the balance is disturbed and the ticking of the clock is audible at the telephone. The arrangement of the coils (A, B, C, D) was the point to be studied, the microphone attachment being of no importance in the combination; for it is well known that a rheotome to break the primary circuit completely at intervals can be substituted for the microphone with advantage.

Fig. 2.



It seemed to me that two of the coils (A B) in the Hughes induction balance might be attached rigidly to a wooden handle, so as to be moved over the seat of the bullet without changing their relative positions, and that all the adjustments necessary might be made on the other pair of coils, which need not be moved from their place, and would not therefore be liable to disarrangement. If a single pair of coils were to be used as in fig. 1, they must be adjustable one upon the other. But if during the course of exploration the coil B (fig. 1) should be moved from its proper position even to the extent only of a small fraction of a millimeter, the balance would be disturbed and the exploration might have to be stopped in order to adjust the apparatus. These considerations led me to the conclusion that some modification of the Hughes induction balance was most suitable for my purpose, and I immediately commenced the construction of such an apparatus.

Suggestions tested.—Just at this time I learned from the newspapers that Prof. Simon Newcomb, of Washington, had the

idea of using a magnetic needle to indicate by retardation of its rotation the proximity of the bullet in the body of the President, and I telegraphed to Prof. Newcomb the offer of my assistance in carrying on experiments, knowing the comparative difficulty he would experience in having apparatus made in Washington.

At his suggestion I tested the point whether the rotation of a leaden disk and of a leaden bullet underneath a delicately suspended magnetic needle would cause a deflection of the needle.

The disk occasioned a deflection, but the bullet produced no sensible effect. I telegraphed the result to Prof. Newcomb, and at the same time took occasion to inform him of the hopeful results I had obtained with the crudely constructed induction balance referred to above.

I was much gratified by his immediate appreciation of the experiment. He telegraphed that he thought an induction balance promised a much more hopeful solution of the problem than his own method, and encouraged me in every way to continue my experiments.

This appreciation determined me to proceed to my laboratory at Washington, where I was accompanied by Mr. Sumner Tainter, who was anxious to assist in such a cause. I learned from Prof. Newcomb that Mr. Geo. M. Hopkins, of Brooklyn, had independently suggested the use of Hughes' induction balance, and had made experiments in Brooklyn, the results of which were published in the New York Tribune on the 11th of July, 1881. Mr. J. Stanley Brown (private secretary of President Garfield) kindly handed to me the letters he had received from Mr. Hopkins, and also a Hughes' induction balance like that shown in fig. 2, which Mr. Hopkins had forwarded to the Executive Mansion for trial.

This apparatus was at once tested in my laboratory, with results slightly better than those I had obtained in Boston.

My Boston apparatus did not give a greater hearing distance than 3 cm., whereas with the Hopkins apparatus I could distinguish effects at a distance of 3.75 cm.

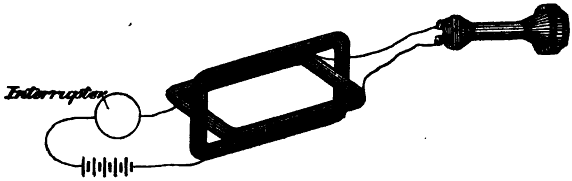
Two of Mr. Hopkins' coils (A B, fig. 2) were then fastened upon a wooden handle to form an exploring instrument, and the whole apparatus was arranged for immediate use in case of any necessity arising for an experiment upon the President. I set myself in communication with Mr. Hopkins, and requested his assistance and coöperation, and in reply received through Private Secretary Brown the following account of further experiments:

"60 IRVING PLACE, BROOKLYN, July 16, 1881.

"MR. J. STANLEY BROWN:

"DEAR SIR: I have made two new instruments on plans differing from that sent, but they yield no better results. The first consisted of two oblong coils arranged at right angles to each other, thus:

Fig. 3.

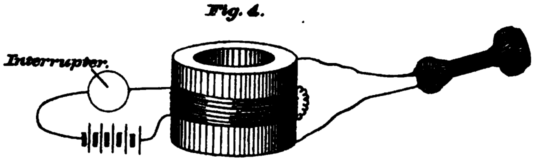


"The outer coil being of coarse wire (No. 18) placed in the primary circuit, the inner coil being of very fine wire (No. 36) and connected with a telephone. The parallel currents traversing the wires neutralized each other, and no audible effects are perceived in the telephone, but on presenting a metallic body to the instrument upon a line bisecting the angle between the coils the clicking in the telephone is heard.

"This instrument possesses only one advantage over that sent, and that is that it requires no adjustment.

"The other instrument consists of two large coils of very fine wire (No. 36) placed upon opposite sides of a coil of coarse wire (No. 16), the fine coil being connected so that the induced currents neutralize each other, thus:

Fig. 4.



"I am sorry to be obliged to say of this as of the other, that it is no more sensitive than the one sent. To produce the best effects from the instrument which you have it will be necessary to use all the battery power possible without burning the coils, and two receiving telephones of the best construction must be used.

"As I stated in the first instance, if the ball is more than two inches deep, I think it cannot be located by this means.

"If larger coils were used the instrument might be operative at a greater distance, but the area indicated as containing the ball would be so large that the result would be indefinite and without value.

"Hoping that Prof. Bell will be able to succeed, I remain,

"Yours very truly,

"GEO. M. HOPKINS."

Prof. Hughes of London, England, Prof. Trowbridge of Harvard College, Prof. Rowland of Johns Hopkins University, and other authorities were consulted by telegraph as to the best theoretical form of induction balance for the purpose required, while empirical experiments were being carried on under my direction in my laboratory at Washington by Mr. Sumner Tainter; in the electrical work-shop of Davis and Watts, in Baltimore, by Mr. J. H. C. Watts, and in the establishment of Mr. Chas. Williams, Jr., in Boston, by Mr. Thomas A. Gleason. To test the influence of size of coil, an instrument was constructed in which the coils were no larger than the bullet for which we sought (as had been suggested by Prof. Newcomb), and experiments were also made with the enormous coils used by the late Prof. Henry in his researches upon induction, which were kindly lent to me for the purpose by the Smithsonian Institution, but neither the small nor the large coils produced more satisfactory results than those we had already obtained.

To test battery power, 20 enormous Bunsen elements, which had formerly been used to light the gas at the Capitol, were placed at my disposal by Mr. Rogers, electrician of the Capitol, but while great electro-motive force was evidently of use we derived no advantage from such a battery as this.

To test the influence of speed of interruption, Mr. Marean, Supt. of the Western Union Telegraph Co. in Washington, kindly lent us an electric motor, by means of which we were able, with the aid of a rotating commutator, to obtain interruptions of the primary circuit of all rates up to 600 interruptions per second,* and we found that the more rapid the rate of interruption the more distinct was the sound in the telephone. The hearing distance, however, was not proportionately increased. The automatic interrupter (shown in fig. 5), yielding about 100 interruptions per second, gave as good results as any, and was much more convenient. This interrupter was therefore afterwards used exclusively in our experiments.

The theoretical form o coil suggested by Prof. John Trowbridge was substantially the same as that proposed by Prof. Rowland, and is shown in fig. 6.

The arrangement was quite sensitive to metal placed in the interior of the coil, but the hearing distance for a bullet external to the coils was no greater than before.†

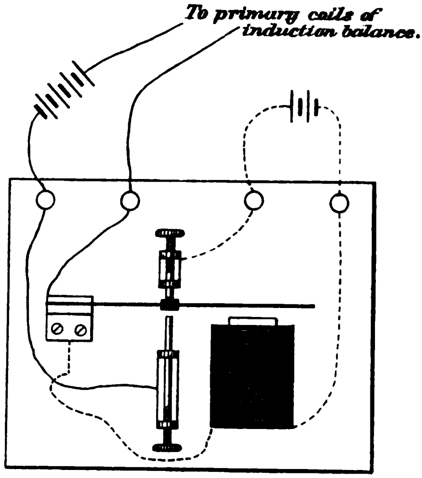
Professor Hughes proposed to have two flat superposed coils wound on a single reel, so that the two coils should form

* Mr. Sumner Tainter has since made an apparatus operating in a similar manner by means of which he has obtained as many as 4,000 interruptions of the circuit per second.

† The balance obtained was not quite perfect, and we have since discovered that the insulation of the wires of one of the secondary coils was defective.

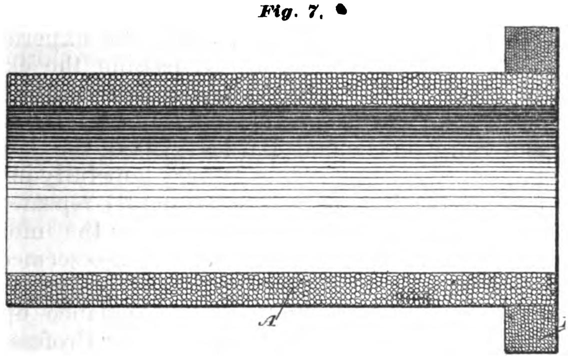
a single one as regards their relative distance; and Mr. F. T. Bickford, Washington correspondent of the New York Tribune, suggested winding two wires side by side into a single coil, so that the relative distances of the wires from the bullet should

Fig. 5.



be absolutely the same. Mr. Charles E. Buell and Dr. Chichester A. Bell proposed to determine the depth of the bullet beneath the surface by causing a similar bullet to approach the balancing coils until silence was restored; the secondary bullet

Fig. 7.



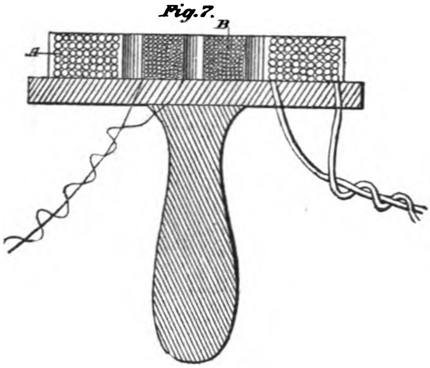
it was presumed would then be at the same distance from the balancing coils as the embedded bullet from the exploring coils.

The results of all the experiments so far made were unsatisfactory. I had tried every thing that had been suggested, but 4^{cm} remained the extreme limit of audibility for a bullet like

that which had struck the President. Even when such a bullet was flattened by being fired against a board, and was presented with its flat side toward the coils of the explorer—the most favorable mode of presentation—no better result was obtained.

Original Experiments.—In the theoretical arrangement recommended by Professors Trowbridge and Rowland (fig. 6) the primary coil A was of smaller diameter than the secondary B. This had given us no better effects than the ordinary form of Hughes' balance (see fig. 2), in which the two coils A B were of equal diameter. We then tried the effect of making the primary coil A of greater diameter than the secondary B (see fig. 7), and in this case we appeared to obtain an increase of

Fig. 7.



hearing distance. Five centimeters (2 inches) was, however, the utmost limit reached, when, on the 19th of July, Mr. J. Stanley Brown and Dr. Woodward visited my laboratory and witnessed some experiments. No difficulty was experienced in detecting a bullet held in the mouth by passing the exploring coil over the cheek; and the presence of a flattened bullet held in the clenched hand was also readily determined. Dr. Bliss, Dr. Reyburn and Surgeon-General Barnes visited the laboratory next day and expressed themselves as very hopefully impressed by the experiments. These were subsequently repeated in the surgeon's room at the Executive Mansion, for the information of Dr. Frank Hamilton and Dr. Agnew, who also seemed favorably impressed.

Such opinions from the surgeons in attendance upon the President, and the continued interest shown by Professor Newcomb, encouraged me to proceed with the experiments.*

It was now determined to test the effect of each convolution of the primary coil, so as to arrive empirically at some idea of

*I desire specially to express my gratitude to Dr. Frank Hamilton for words of encouragement spoken at a later date when sympathy and encouragement were greatly needed.

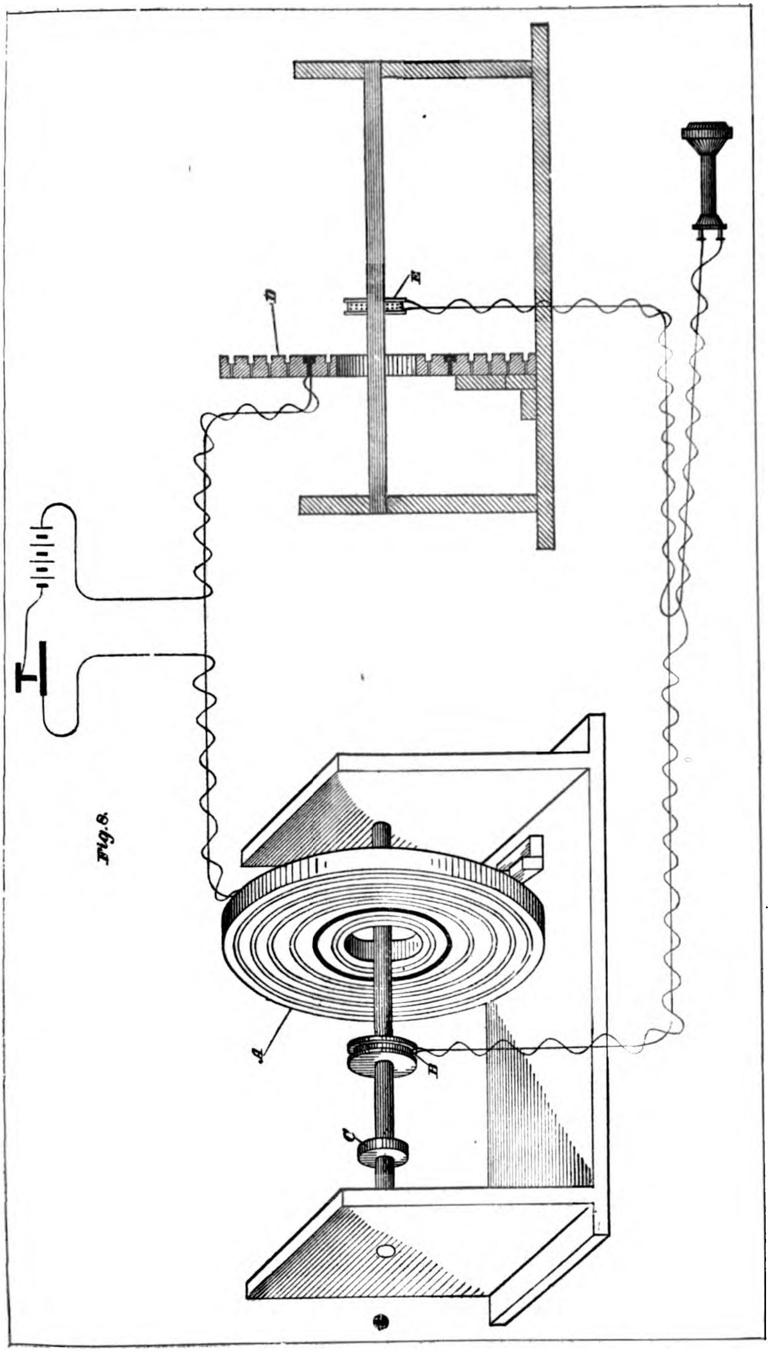


Fig. 8.

the best shape of coil. For this purpose Mr. Tainter constructed the instruments shown in fig. 8. Circular grooves were turned in two boards, one of which is shown in perspective at A and the other in section at D. An insulated copper wire could be pressed into any of these grooves, so as to give the wire an exactly circular shape of known diameter, and the two ends were passed through an orifice in the back of the board, making connection with a similar ring of wire in the other instrument as shown. A small secondary coil (B) of fine wire, which could be moved with moderate friction upon the horizontal rod, was connected to another similar coil (E), and to a telephone; and a small brass ring (C), which could also be moved along the horizontal rod, was used instead of a bullet to disturb the balance.

In making an experiment with this apparatus the secondary coil (B) was first placed within the primary ring and in the same plane with it, and the balancing coil E was adjusted to produce silence. The brass ring C was then moved along the horizontal rod until the balance was sensibly disturbed and the relative distances of the coils and the brass ring were noted.

RESULTS OF A SERIES OF EXPERIMENTS MADE ON THE 19TH OF JULY, 1881.

Diameter of Primary Ring.	Distance between—			Diameter of Primary Ring.	Distance between—		
	A B	B C	A C		A B	B C	A C
mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
	0	17	17		0	27	27
	5	14	19		5	20	25
30	10	13	23	159	10	18	28
	20	9	29		20	17	37
	30	7	37		30	14	44
	50	0	50		50	14	64
	0	17	17		0	12	12
	5	19	24		5	18	23
50	10	26	36	206	10	25	35
	20	17	37		20	19	39
	30	14	44		30	22	52
	50	5	55		50	18	68
	0	21	21		0	20	20
	5	23	28		5	18	23
81	10	23	33	253	10	20	30
	20	18	38		20	19	39
	30	14	44		30	23	53
	50	12	62		50	20	70
	0	22	22				
	5	25	30				
113	10	27	37				
	30	26	46				
	30	26	56				
	50	17	67				

Continuing the experiment, the coil B was moved a determined distance beyond the plane of A, and the balancing coils again adjusted to silence. The brass ring C was once more caused to disturb the balance, and the new hearing distance was noted. The results of a series of experiments made on the 19th of July, 1881, are tabulated on the preceding page. The battery employed consisted of six bichromate cells connected in series.

These figures show that *the distance from the primary coil* A (fig. 8) *at which the influence of the brass ring* C *became perceptible increased with the diameter of the primary ring, and that the secondary coil* B *required to be projected considerably beyond the plane of the primary in order to obtain the maximum effect.*

The conclusion seemed a natural one that the degree of projection A B of the secondary coil should proportionally increase with the diameter of the primary ring, but the tabulated figures did not fully justify the inference.

The experiments had necessarily occupied a considerable time, and I thought that the difference between the results that should have been observed, according to the above hypothesis, and those that were actually obtained, might have been due to the gradual exhaustion of the bichromate battery employed and to its polarization, although every care had been taken to preserve its power by removing the carbon and zinc plates from the solution, excepting when an observation was made. To test whether the battery exerted any material influence upon the hearing distance, a further series of experiments was made with the same battery.

It will be seen by reference to the tabulated statement shown above that the maximum hearing distance B C had been obtained with a primary ring 11·3^{cm} in diameter when the distance A B between the primary and secondary coils was one centimeter. This arrangement of the apparatus was therefore adopted throughout the following experiments:

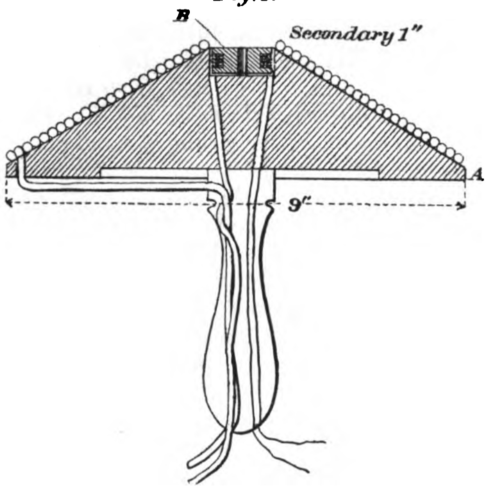
		Hearing distance.
1. Apparatus tried with 1 cell (bichromate battery)	(B C, fig. 8) =	9^{mm}
2. Six cells in series	(B C, fig. 8) =	16^{mm}
3. Six cells in multiple arc	(B C, fig. 8) =	9^{mm}
4. Six cells in two series of 3 each	(B C, fig. 8) =	15^{mm}
5. Same experiment repeated	(B C, fig. 8) =	13·5^{mm}
6. Same experiment repeated by Mr. Tainter	(B C, fig. 8) =	12·5^{mm}

These experiments proved that battery power *did* exert an influence upon hearing distance, and also that the battery in use was gradually deteriorating.

I concluded, therefore, that if the battery power had remained constant, the hearing distance might not only have been proportional to the diameter of the primary ring, but, in order to attain the maximum effect, the projection of the secondary coil beyond the plane of the primary might also have been found to increase in like proportion.

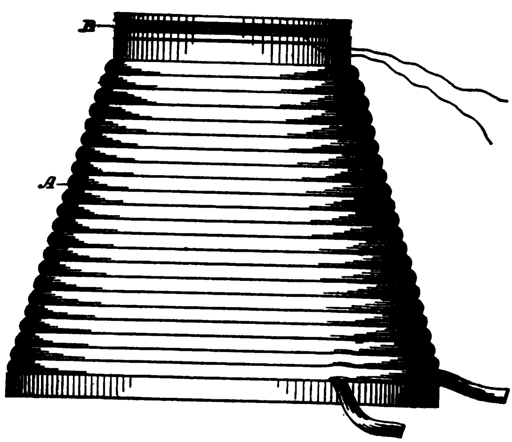
This led me to try the effect of a conical primary coil A with the secondary B at its apex, as shown in fig. 9, but the hearing distance for a bullet was only 3·5^{cm}.

Fig. 9.



Singularly enough Mr. J. H. C. Watts, in Baltimore, had independently arrived at a very similar form of coil, and with the instrument shown in fig. 10 he had obtained at one time a

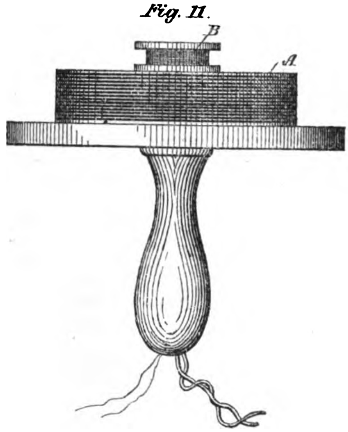
Fig. 10.



hearing distance of 7·5^{cm} (or 3 inches), but from some cause not ascertained he was unable subsequently to reproduce the effect.

The final form of apparatus adopted as the result of the above experiments is shown in fig. 11. With this arrange-

Fig. 11.



ment and a battery of six bichromate elements freshly set up, we were always sure of a hearing distance of at least 5^{cm}, although after the battery had been in use for some time the hearing distance hardly exceeded 4^{cm}.

The following are the dimensions of the coils A B (fig. 11) and their resistance:

Coil A	External diameter	7^{cm}
	Internal diameter	$4{\cdot}5^{cm}$
	Depth	$2{\cdot}4^{cm}$

Wire used, No. 23 (cotton covered). Resistance, 2 ohms.

Coil B	External diameter	$2{\cdot}3^{cm}$
	Internal diameter	8^{mm}
	Depth	8^{mm}

Wire used, No. 36 (silk covered). Resistance, 75 ohms.

The face of the coil B projected beyond the face of coil A 4^{mm}.

The balancing coils were made as nearly as possible the duplicates of A and B. The resistance of the coil of the telephone employed was 75 ohms.

Influence of Battery Power.—The following experiments were made with this apparatus (fig. 11) on July 20th, 1881, to test the influence of battery arrangements upon the hearing distance of a leaden bullet:

I. *Series of experiments with a bichromate battery which had previously been in use for a few minutes.*

	Hearing distance of leaden bullet as observed by—	
	A. G. Bell.	S. Tainter.
	cm.	cm
1 cell	2·4	2·6
2 cells in series	3·3	3·5
3 cells in series	3·7	4·1
4 cells in series	3·7	4·0
5 cells in series	4·0	4·1
6 cells in series	4·3	4·4
6 cells in multiple arc	2·6	2·9
6 cells in two series of 3 each	3·8	3·7
6 cells in three series of 2 each	4·3	4·0

II. *Series of experiments with a Leclanché battery of twenty cells which had been set up for about one month. It had been kept normally upon open circuit, and had only been occasionally used.*

	Hearing distance.
20 cells in series	3·3cm
20 cells in 10 series of 2 each	3·6cm
20 cells in 5 series of 4 each	4·1cm
20 cells in 2 series of 10 each	3·3cm

Although the battery appeared to be in good condition, a close inspection showed that the connections were dirty, and that one of the zinc wires was half broken through.

The defective cell was now removed from the circuit, and the connections of all the other cells cleaned and tightened.

III. *The following experiments were then made with the Leclanché cells united in series:*

No. of cells.	Hearing distance. cm.	No. of cells.	Hearing distance. cm.
1	2·7	11	3·8*
2	2·8	12	4·2
3	3·0	13	4·2
4	3·3	14	4·2
5	3·5	15	4·3
6	3·5	16	4·2
7	3·6	17	4·2
8	3·8	18	4·2
9	4·0	19	4·2
10	3·8*		

These results are graphically represented in fig. 12.

It will be observed that the hearing distance was carried nearly one-third as far again as at first, simply by increasing the number of cells employed without any other change in the

* Balance not quite perfect.

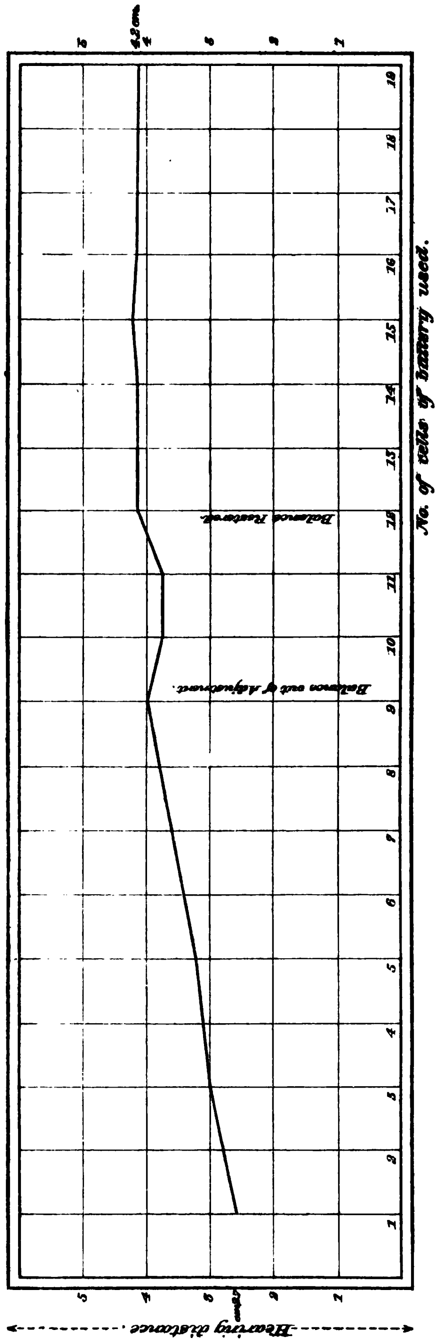

No. of cells of battery used.
Balance Restored.
Balance out of Adjustment.
Hearing distance
4.2 cm.

Fig. 12.

arrangement. It will also be noticed that the apparatus required to be adjusted to complete silence in order to obtain the maximum effect.

As a general result of all our experiments with voltaic batteries, we find that *it is advisable to use a battery possessing great electro-motive force and slight internal resistance, and to connect the cells in series.*

Experiments upon Living Subjects.—On the 22d of July an experiment was made at the request of Dr. Bliss upon the person of Lieut. Simpson, who had carried a bullet in his body for many years.

When the exploring instrument (fig. 11) was passed over the lieutenant's back a sonorous spot was found, but the indications were too feeble to be implicitly relied upon. Imagination very easily conjures up a feeble sound like that observed, but a number of experiments by different observers seemed to indicate that in this case there was an external cause for the sound—probably the presence of a very deeply-seated bullet. The results of this experiment were communicated to Dr. Bliss in a letter dated July 23d, 1881.

On the 25th of July, Prof. Rowland visited me at Washington, and suggested the use of a condenser in the primary circuit. I had previously discussed this idea with Mr. Tainter, but, not having a condenser at hand, we had been unable to make any experiment. After our conversation with Prof. Rowland, however, we were so impressed by the importance of the point that we obtained a condenser next morning, and found it to produce not only a different quality of sound when the bullet approached the coils, but also to increase the hearing distance of the instrument shown in fig. 11 at least one centimeter.

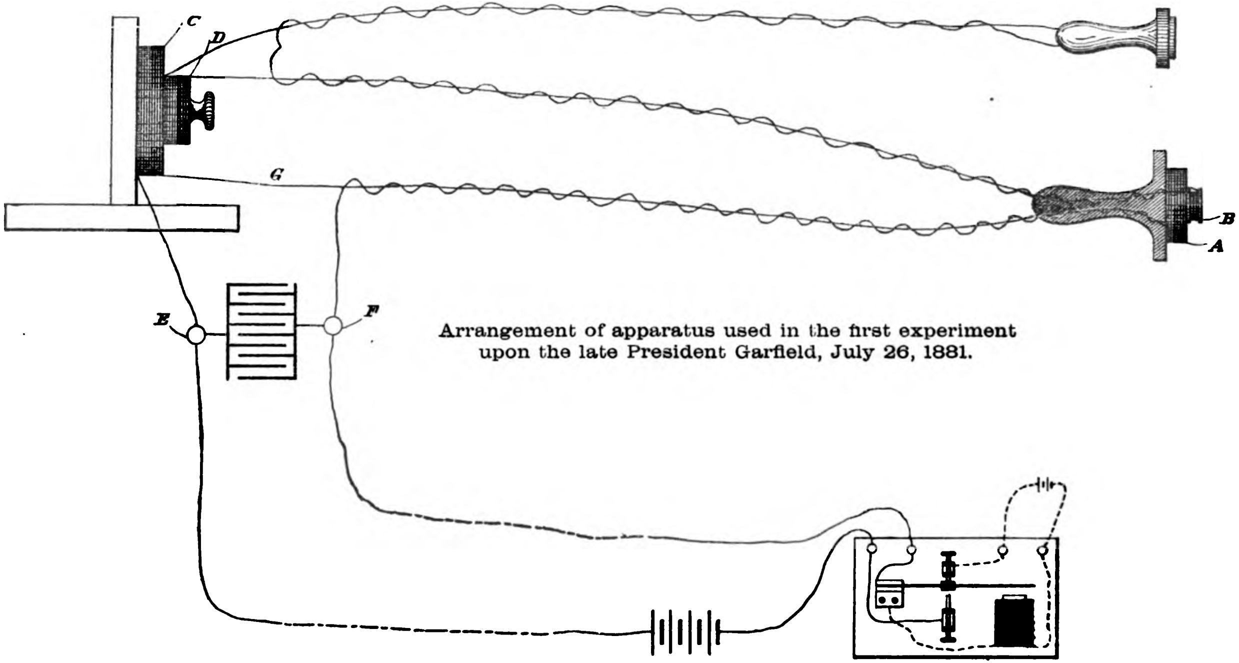
On the evening of the same day (July 26th) our apparatus was carried to the Executive Mansion, and an experiment made upon the person of the President.

From some cause then unknown a balance could not be obtained, and the results were therefore uncertain and indefinite. It was discovered afterwards that a mistake had been made in the mode of connecting the condenser. The latter should have been connected at E F (fig. 13), whereas it was placed at E G, thus influencing only one, instead of both, of the primary coils.

With the condenser properly arranged experiments were tried on July 29 and 30 on three soldiers from the Soldiers' Home who had been wounded during the civil war, namely, John Teahan, Asa Head, and John McGill.

In the case of John Teahan no results were obtained. In the case of Asa Head, who had a buckshot in the cheek, loud

Fig. 13.



Arrangement of apparatus used in the first experiment upon the late President Garfield, July 26, 1881.

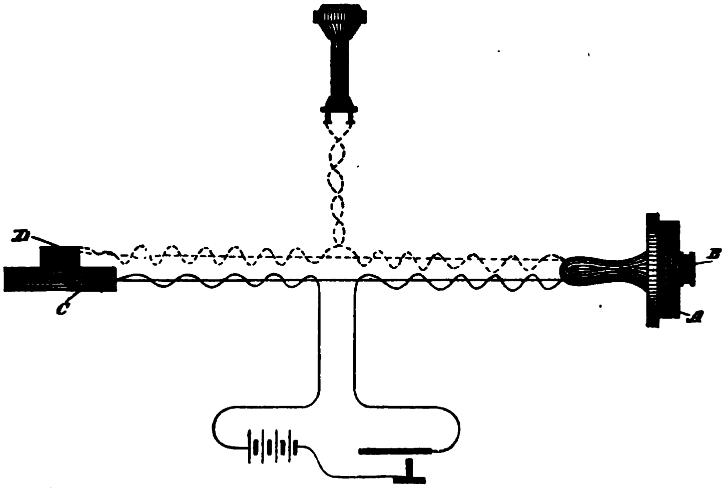
and well-marked sounds were heard in the telephone; and in the case of John McGill, who was supposed to carry a bullet in his back, no results were obtained.

Further efforts were then prosecuted for the improvement of the apparatus.

Further experiments to improve apparatus.—Our attention had hitherto been directed chiefly to modifications of the exploring instrument. We now investigated the effect upon the hearing distance, of the coils used to obtain a balance.

The following experiments, made July 29, 1881, bear upon the point:

Fig. 14.



Exp. 1. (See fig. 14.) Resistance of primary A of exploring instrument, 2 ohms; resistance of primary C of balancing coils, also 2 ohms; resistance of exploring secondary B, 140 ohms; and of balancing secondary D, 120 ohms.

Result: Hearing distance of bullet from explorer A B, 3·5^{cm}. Hearing distance from balancing coils C D, also 3·5^{cm}.

Exp. 2. (See fig. 15.) Same exploring coils as in Exp. 1, but balancing coils consisted of a flat primary, E—resistance, 5·30 ohms; and flat secondary, F—resistance, 83 ohms. The adjustment was made by sliding the secondary coil upon the primary until a position of silence was obtained.

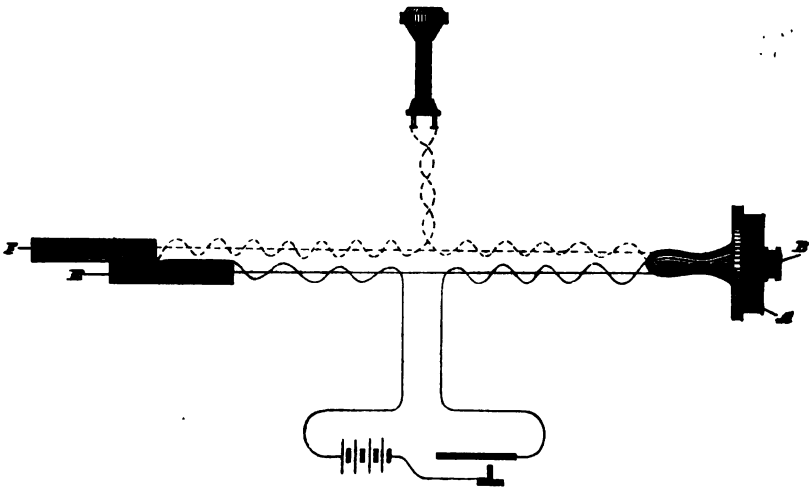
Result: Hearing distance from explorer A B, 1·5^{cm}. Hearing distance from E F, 3^{cm}.

As a general result of our experiments we found that *every increase in the resistance of the balancing coils (especially the primary) reduced the hearing distance of the exploring instrument,*

and it became therefore desirable to do away with this source of resistance as much as possible.

Return to original form of apparatus.—This led us back to the original form of apparatus that had first occurred to me (see fig. 1), in which a single pair of coils was employed. A few other experiments, made July 29, 1881, will show the importance of the point attained.

Fig.15.

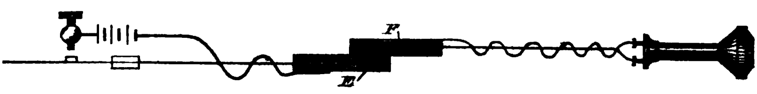


Exp. 3. The two flat coils E F used in experiment 2 were arranged as in fig. 16, so as to form a balance by themselves.

Result: Hearing distance, 7^{cm}.

In all these experiments the battery used consisted of four cells (Leclanché.)

Fig.16.



Exp. 4. The same coils used in Exp. 3 were tried again, as shown in fig. 16, but with a battery of eight cells (Leclanché.)

Result: Hearing distance, $8{\cdot}7^{cm}$, or nearly $3\frac{1}{2}$ inches—a result quite unprecedented in our experiments.

The following are the dimensions of the coils E, F.

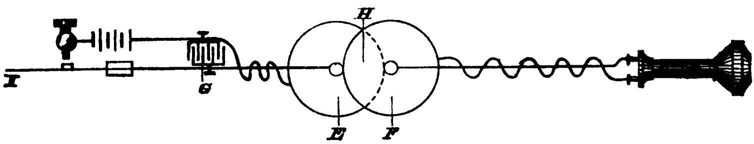
Coil E	External diameter	10 cm
	Internal diameter	2·5cm
	Depth	1 cm
	Wire used, No. 23, (silk-covered.)	
Coil F	External diameter	10 cm
	Internal diameter	2·5cm
	Depth	1 cm
	Wire used, No. 28, (silk-covered.)	

Exp. 5. The same coils E F, used in Exps. 2, 3 and 4, were tried once more with a battery of six large bichromate elements, and with a condenser, G, in the primary circuit as shown in fig. 17.

Result: Hearing distance 13^{cm}, or more than 5 inches.

This great increase in hearing distance seemed to be chiefly due to the condenser, for upon disconnecting it the hearing distance was little more than 9^{cm}, but further experiments proved that other causes also contributed to the result.

Fig. 17.



Exp. 6. When the condenser was in circuit and the leaden bullet close to the coils (arranged as in fig. 17) the sound produced by the telephone was a musical note whose pitch was the same as that normally produced by the vibration of the reed of the interrupter. Mingled with this tone could be distinguished a number of feebler tones of very much higher pitch. Upon withdrawing the bullet gradually from the coils the fundamental sound became fainter, and one of the high upper-partial tones gradually acquired prominence; and at a distance of about 8 or 9^{cm} the fundamental could no longer be distinguished, but the high tone persisted, and was clearly audible up to a distance of 13^{cm}. The effect was very striking, and when the bullet was moved to and fro parallel to the plane of the coils E F at a distance of about 10^{cm}, the telephone emitted a shrill whistling sound each time the sensitive area (H) was passed.

It was noticed that other metals, such as iron, brass and copper, did not seem to reinforce this high tone to any great extent, but brought out the fundamental at every distance where an effect was produced.

Exp. 7. The condenser G (fig. 17) was removed from the circuit and the leaden bullet held about 4 or 5^{cm} from the coils E F. The fundamental tone was heard, and the characteristic upper partial could also be distinguished, but it was only faintly audible. Upon now suddenly replacing the condenser the high upper-partial tone was instantly reinforced as if by a resonator.

Exp. 8. The rheotome employed to interrupt the primary circuit (which had been placed in a distant room) was found to be vibrating badly. The reed I of the instrument (see also

fig. 5) was rattling against its contact pieces, thus producing an impure sound, and I could distinguish among the upper-partials the tone that had been reinforced by the condenser. Upon screwing up the contact pieces so as to improve the vibration I could no longer distinguish the particular upper-partial referred to, and upon returning to the room in which the coils E F (fig. 17) were placed I could no longer detect the effects noted above in Exps. 6 and 7, and the hearing distance did not exceed 9^{cm}.

The peculiar effects obtained with the arrangement shown in fig. 17 *thus seemed to depend* (1) *upon a particular kind of vibration of the reed of the interrupter, producing a certain high upper-partial or overtone* (2), *upon the use of a condenser acting as a sort of electrical resonator for this tone, and* (3) *upon the use of the metal lead.*

Mr. Marean, of Washington, kindly lent me a number of condensers used by the Western Union Telegraph Co., and we found, upon connecting them with the coils E F, as shown in fig. 17, and, holding a leaden bullet near the coils, that each condenser reinforced a high upper-partial of different pitch. We arranged the condensers so that they could be successively introduced into the circuit with great rapidity. The effect was very curious, and sounded somewhat like a Scotch air played upon the bag-pipes. The low hum of the fundamental could be heard continuously, like the drone of the bag-pipe, while the higher tone changed its pitch with each change of condenser.

The pitch of the high tone reinforced seemed to depend upon the electro-static capacity of the condenser employed, but the exact relation between the two has not been ascertained. In experiments 5, 6, 7, 8, and the subsequent experiments described above, the battery employed consisted of six pairs of carbon and zinc plates of large area placed in a solution of bichromate of potash containing sulphuric acid.

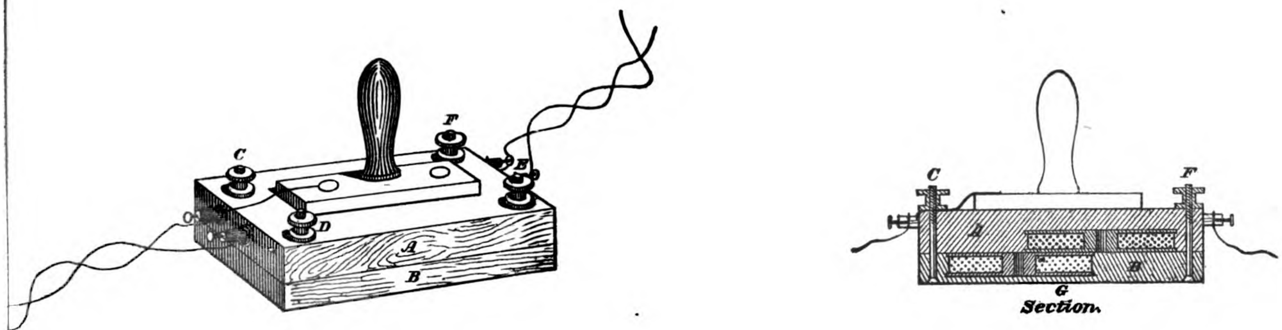
The effects noted above were not produced satisfactorily when the battery was much run down, nor were they obtained with a Leclanché battery which had been set up for some time, but which appeared to be in good condition.

It is evidently necessary in order to produce this characteristic high tone to use a battery possessing considerable electromotive force and slight internal resistance.

Our experiments had reached this stage when, on Saturday, the 30th of July, 1881, I was requested to make another trial upon the person of the President at the evening dressing of the wound.

At this time, however, we had no exploring instruments completed excepting one or two like that shown in fig. 11; for it will be understood that the promising results noted above

Fig. 13.



Apparatus used in the second experiment upon the late President Garfield, August 1st, 1881.

had been obtained from coils that were simply placed upon a table and adjusted by hand.

We immediately proceeded to the Executive Mansion with the apparatus shown in fig. 13, prepared to make a trial, if it was deemed advisable; but upon learning of the results of our later experiments the surgeons resolved to postpone any further trial until we could arrange the coils (fig. 17) in a portable form.

By forced exertions the coils were arranged that same night in a wooden case, as shown in fig. 18. This case consisted essentially of two oblong blocks A B. A shallow circular recess was turned out in each block for the reception of one of the coils, and the two blocks were held together by four pins of ebonite, C, D, E, F, which passed up through slots in the upper block and were secured by ebonite thumb-screws.

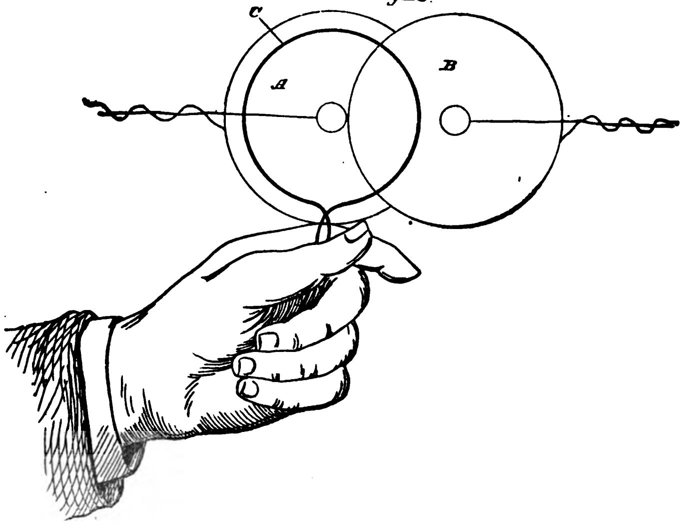
When the instrument was completed I found to my great distress that a balance could not be obtained by any adjustment of the apparatus. There was a position of minimum sound, and the telephone responded to a bullet presented to the central part G of the instrument; but the hearing distance did not exceed 3 or 4^{cm}, whereas we had obtained with the same coils before the construction of the wooden case a perfect balance and a hearing distance of 13^{cm}.

After numerous unsuccessful experiments had been made to ascertain the cause of the difficulty it occurred to me that if two adjoining convolutions in one of the coils, made contact at any point, a circuit of low resistance would be formed (a single ring of wire, in fact), in which the induced currents might circulate without reaching the telephone connected with the apparatus. I had previously measured the resistance of the coils without discovering any defect, but when I considered the large number of convolutions in each coil it seemed possible that a defect of this kind might exist which could not be discovered by a Wheatstone Bridge, excepting by very delicate and accurate observations. To test whether a short-circuited convolution would produce effects analagous to those observed, a piece of copper wire was bent into an annular form and the ends connected together. On bringing this metallic ring near a pair of coils (A, B, fig. 19), properly adjusted to silence, the balance was loudly disturbed. The copper ring (C) was held as shown in fig. 19, and the balance could not then be restored by any adjustment of the coils. A position of minimum sound was all that could be obtained, and the hearing distance was enormously reduced. This was *prima facie* evidence of the nature of the defect.

The coils (fig. 18) were then removed from their case, but a cursory examination revealed no defect. Upon trial, however

(being arranged, as formerly, in fig. 17), a balance could not be obtained, and the hearing distance was only about 4^{cm}. The defect was thus definitely located in the coils themselves.

Fig. 19.



Upon close examination it was noticed that the outside convolutions of the primary coil were slightly frayed at one part, but it appeared hardly possible that so great a defect could be due to so apparently slight a cause. However, to test the matter, I removed the outside layer of wires and then tested the coils again.

Result: The defect had vanished—a perfect balance was obtained, and the hearing distance was again 13^{cm}.*

* These experiments have revealed the cause of the extreme difficulty always experienced in obtaining a perfect balance with coils of fine wire. I have recently used an Induction Balance to test the condition of the helices that were employed in these researches, and have discovered that in a large percentage of cases the insulation was defective. It is possible that some of the results described in this paper (especially of the earlier experiments) may have been vitiated by errors due to defects in the coils that were not suspected at the time. A defect of insulation that is quite immaterial for ordinary purposes may be absolutely fatal to the success of an Induction Balance. Indeed, so much care is required in this respect that it is extremely difficult to obtain coils that are perfectly suitable for an apparatus intended to search out a bullet imbedded in the body. I now make it a rule to test every helix used in Induction Balance experiments by bringing it up to a system of balanced coils like that shown in fig. 19.

1. If the helix is perfect the balance is not disturbed until the terminals of the coil are connected.

2. If there is a break in any of the convolutions the balance is not disturbed, even when the terminals are connected.

3. If a convolution is short-circuited the balance is disturbed, even though

The coils were then replaced in their case and the completed instrument tested. The lower wooden block B (fig. 18) was adjusted by hand as nearly as possible to the position of silence, and then the thumb-screws C, D, E, F were tightened.

The balance now obtained was not quite perfect, but by striking the lower block B, a few smart blows with a wooden mallet we were able to reduce the arrangement to complete silence.

The instrument was then in such a sensitive condition that it could scarcely be moved without affecting the balance. Upon gently swaying it backward and forward a pulsation of sound was heard at every swing.

When the motion was carefully made, so that it was always in the same plane, no pulsations were observed. They only occurred when the inclination of the coils was changed.

This defect was found to be due to the bulging of the thin portion G of the wooden case (fig. 18) under the weight of the enclosed coil, and the simple pressure of a finger on this portion of the case disturbed the balance. The movement of the lower coil when the instrument was swayed about must have been inconceivably small but on account of the extreme sensitiveness of the arrangement it produced a perceptible effect upon the balance.

The pulsating sound did not seem to interfere with the detection of a bullet held in the clenched hand, nor did it seem to affect the hearing distance. I therefore despatched a messenger to the Executive Mansion (Sunday morning, July 31st), with a note for Dr. Bliss, to let him know that the instrument was in a condition to be used, should any necessity arise for an immediate experiment. At the same time I informed him that the apparatus in its present form was very crudely constructed, and that I hoped to improve it very greatly in the course of a few days. On Sunday afternoon (July 31st) we sent to the Soldiers' Home for John McGill, upon whom we had experimented the previous day without results (using the apparatus shown in fig. 11).

Upon trying the new instrument (fig. 18) we had no difficulty in finding a sonorous spot in his back, at the place where the bullet was always supposed to be.

This result was at once communicaied to Dr. Bliss, and in

the terminals are not connected, and the sound produced is the fundamental of the rheotome employed to interrupt the primary circuit.

4. If the insulation is defective the balance is disturbed, although the terminals are not connected, and a peculiar spluttering effect is noticed like that produced by a series of sparks.

I propose to apply this method practically as a means of testing the condition of the helices used in the construction of Induction Coils and those employed in the manufacture of telephones.

reply we were requested to make the experiment upon the person of the President next morning.

On Monday morning (August 1st, 1881) we accordingly removed our apparatus to the Executive Mansion.

The late President Garfield.—During the former experiment (July 26) a sudden sonorous effect had been observed upon passing a point near the spot where the surgeons suspected the bullet to be lodged, but I had been unable to verify this by a second observation, although the exploring instrument (A B, fig. 13) was repeatedly passed over the same place. The sound had been so loud and well marked that I believed at the time it must have been caused by a sudden irregularity in the vibration of the reed of the rheotome used to interrupt the primary circuit, for the arrangement, as explained above, was not perfectly balanced, and any irregularity of this kind would, under these circumstances, have affected the telephone. At the same time the coincidence was remarkable that the exploring instrument should have been at that very time so near the suspected seat of the ball, and this led to the thought that perhaps after all the bullet had been the cause of the sound. I felt confident that the new instrument (fig. 18) would at once decide the question, for the extreme hearing distance of the former apparatus (fig. 13) was only 6^{cm}, and the apparatus shown in fig. 18 was so superior in this respect that if the sound had really been due to the bullet we should obtain with the new instrument distinct and well-marked effects. When the new explorer (fig. 18) was passed over the suspected spot nothing was heard excepting a slight pulsating sound as the instrument was moved to and fro. This was evidence to me that the former sound had been of accidental origin, whether the bullet was there or not. With the view of eliminating any error of observation caused by the pulsations due simply to the movement of the instrument, I lifted the latter (without changing the inclination of the coils) to a height of about 50 centimeters above the body of the President, and moved it to and fro in as nearly as possible the same way I had done at the lower elevation.

I presumed that if the pulsations heard were due simply to the movement of the instrument, they should occur with equal strength at the two elevations; but if any portion of the sonorous effect was due to the influence of the bullet, the pulsations at the two elevations would be different in intensity. I was struck by the fact that, although the sonorous pulsations were very feeble, they were sensibly louder when the instrument was close to the surface of the body than when it was raised. Continuing the exploration, I found a considerable area over which similar effects were noticed, but upon carrying the in-

strument toward the back of the President, the difference between the pulsations produced at the two elevations grew less and less, and finally could not be distinguished.

The difference in the loudness of the sound at the two elevations was so slight that it probably would not have been noticed by an ear unaccustomed to listen to feeble effects, and I feared that the general expectation that the bullet would be found in that part of the body might have led me to imagine a difference that did not exist. For the purpose of eliminating as far as possible any personal error, I requested Mr. Sumner Tainter (who was the only other person present whose ear had been sufficiently trained to be reliable in such an emergency) to repeat the experiments and let me know the result. Upon our return to my laboratory we compared notes, and I found that his observations tallied with mine. He declared he could not obtain a distinctly localized effect, but stated that he had observed a reinforcement of the pulsation over an area of at least two inches in the neighborhood of the spot to which his attention had primarily been directed, and that he was convinced that the bullet was within that area.

It appeared reasonably certain that the area of feeble sound was due to some external cause, and was not simply an effect of expectancy. In the absence of any other apparent cause for the phenomenon, I was forced to agree in the conclusion that it was due to the presence of the bullet, and I so stated in my report to the surgeons. I was by no means satisfied, however, with the results obtained, for no such effects had been observed before in our experiments with bullets. I tried to reproduce the effects by moving the instrument (fig. 18) at different distances over a bullet, but in every case where an effect was produced the sound was quite sharply localized. I thought that perhaps the body of the patient might have affected the result, and so experimented upon a bullet buried in a piece of meat, but no difference of effect was noted. This led me to fear that the extensive area of feeble sound might have been due to some extensive area of metal that was unsuspected at the time, and I proceeded to the Executive Mansion next morning (August 2) to ascertain from the surgeons whether they were perfectly sure that all metal had been removed from the neighborhood of the bed. It was then recollected that underneath the horse-hair mattress on which the President lay was another mattress composed of steel wires.

Upon obtaining a duplicate, the mattress was found to consist of a sort of net of woven steel wires, with large meshes. The extent of the sonorous area having been so small, as compared with the area of the bed, it seemed reasonable to conclude that the steel mattress had produced no detrimental

effect.* I was unable to continue experiments with the steel mattress, as just at this time I was obliged to leave Washington on account of illness in my family. Although I was unable for a long time afterwards to carry on personally induction balance experiments, the investigations were ably continued under my direction by Mr. Thomas Gleason, in the establishment of Mr. Charles Williams, Jr., in Boston.

Experiments continued in Boston.—Mr. Tainter forwarded from Washington drawings of an improved apparatus he had designed to remedy the defects of the instrument shown in fig. 18, in which the case, adjusting screws, etc., were all to be composed of ebonite.

Mr. Gleason constructed for me a number of such ebonite instruments differing slightly from one another in detail, and the apparatus shown in fig. 20 combined the different points that had been approved.

The two coils A B were eccentrically arranged in two circular disks of ebonite, C D, and the adjustment was obtained by means of an ebonite key O, like the key used for tuning pianos, which turned a cam M pivoted in the upper disk and working in a slot N in the lower disk.

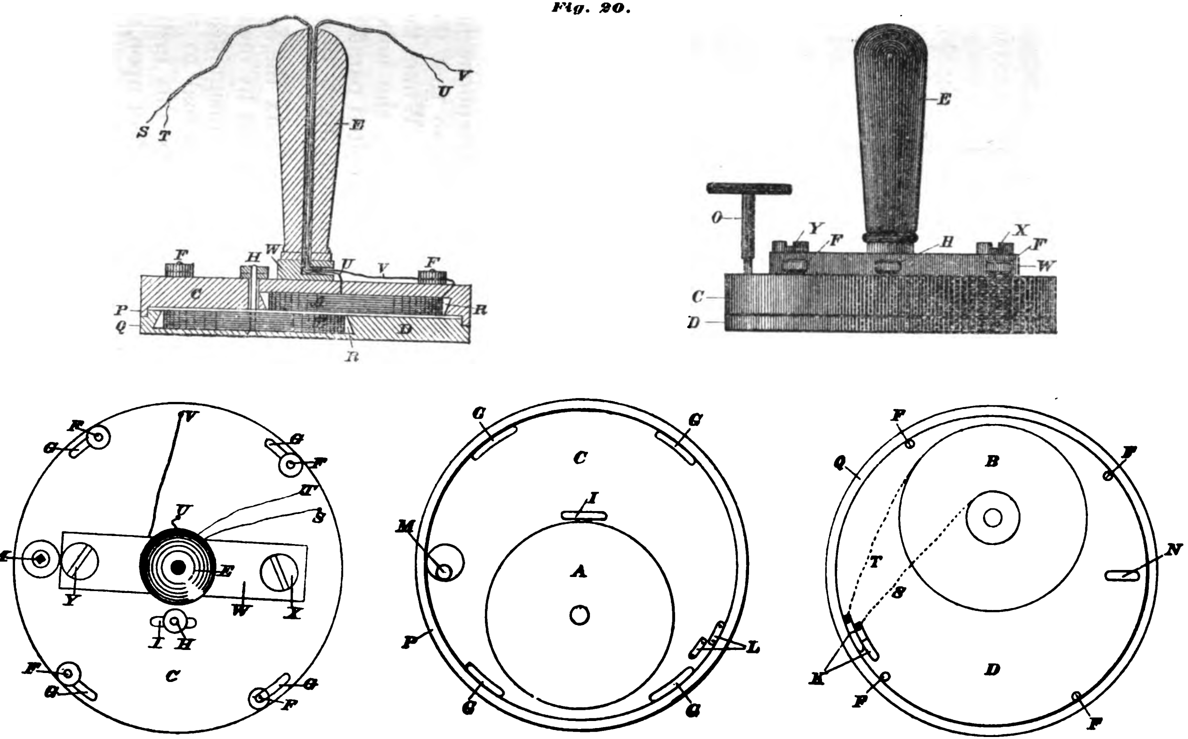
In order to prevent any movement of the coils, excepting that produced by the adjusting-key O, each coil was placed in a recess turned out in its ebonite disk, the edges of which were bevelled as shown at R. Paraffine was then poured in so as to fill up each recess. But this alone did not prevent a slight pulsation of sound when the instrument was swayed from side to side, and a very slight pressure of the finger on the thin portion of the ebonite plate under the coil B was sufficient to destroy the balance.

This was remedied by strengthening this portion by means of a rod of ebonite, which passed up through the center of the coil and through a slot I, in the upper ebonite plate, and was clamped firmly after the adjustment of the instrument by an ebonite thumb-screw H. This, however, increased the difficulties of adjustment. When the coils were adjusted to silence, then the tightening of the thumb-screw H disturbed the balance; and if the thumb-screw H was tightened first, then the adjustment could only be made by a series of jerks, on account of friction. In practice we found it best to adjust the instrument *almost to silence*, and then the tightening of the thumb-screw H completed the balance.

This was the form of apparatus at which we had arrived at the time of the death of President Garfield.

* The death of President Garfield and the subsequent *post-mortem* examination, however, proved that the bullet was at too great a distance from the surface to have affected our apparatus.

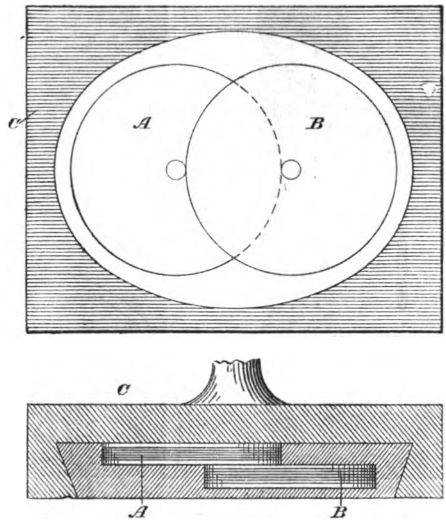
Fig. 20.



The difficulty of adjusting the coils led me ultimately to the idea of the apparatus shown in figs. 21, 22, 23, 24, which is the most practical form of the instrument yet devised.

The two exploring coils A B (fig. 21) are arranged as shown, in a recess turned out in a single block of wood C.

Fig. 21.



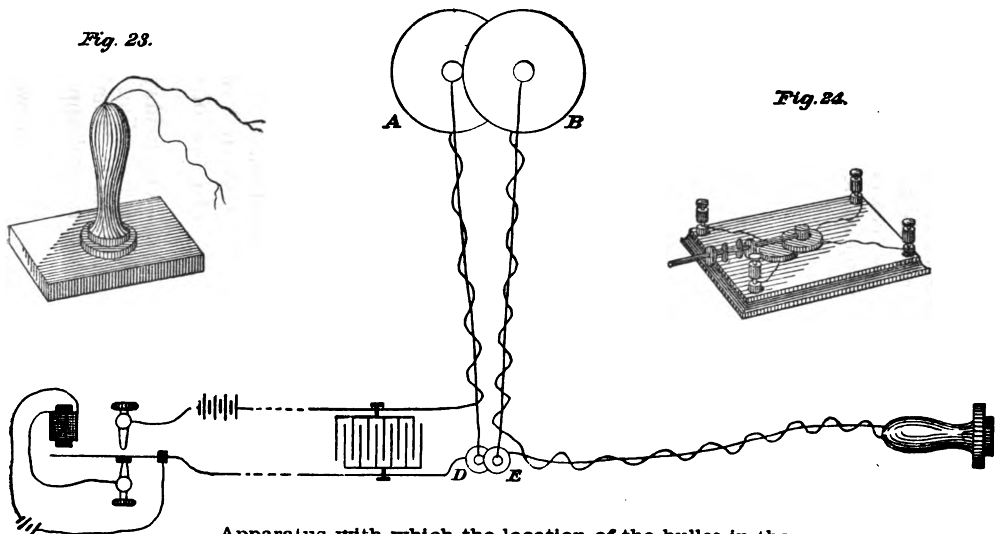
The coils are temporarily connected with a telephone battery and rheotome in the manner shown in fig. 1, so that they may be adjusted by hand to form a balance. When they have been arranged in their position of silence, the hollow in the block of wood C (fig. 21) is filled with melted paraffine. Upon cooling, the two coils are found immovably fixed in one solid cake of paraffine.

As a matter of practice it is found impossible to fix the coils in this way exactly in their position of silence; but by means of two other very small coils, D E (fig. 22), of insignificant resistance, forming a sort of fine adjustment external to the explorer, a perfect balance is easily obtained. In this instrument the swaying of the coils A B produces no effect upon the balance.

The completed arrangement is shown in plan in fig. 22, and the explorer and balancing coils are shown separately in perspective in figs. 23 and 24.

On account of the small size and slight resistance of the balancing coils we were enabled to make the adjustable parts of the balancer of metal without practical interference with the sensitiveness of the exploring instrument, and this gave us the

Fig. 23. *Fig. 22.* *Fig. 24.*



Apparatus with which the location of the bullet in the body of Col. Clayton was discovered, Oct. 7th, 1881.

power of making very delicate adjustments of the balancing coils.

We found it advisable, however, to avoid placing metal over the sensitive area of the coils as had been done in the instrument shown in fig. 24.

In the balancing apparatus shown in fig. 25 (which is the most perfect one yet constructed), the lever to which the upper coil is attached is made of hard rubber.

In fig. 26 is shown the most convenient form of case yet devised for holding the exploring coils.

Fig. 25.

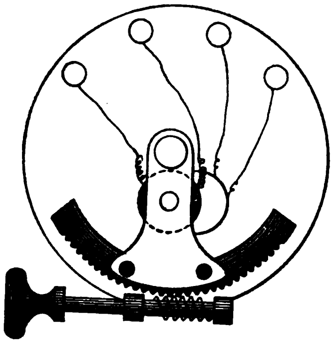
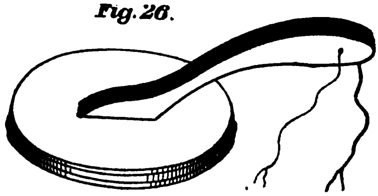


Fig. 26.



By invitation of Dr. Frank Hamilton experiments were made at his office in New York, October 7, 1881, the instruments used being those shown in figs. 22, 23, 24.

As this was the first successful application of the Induction Balance to the discovery of the situation of a ball in the body the position of which was previously unknown, I may be pardoned for entering somewhat into detail.

I shall quote from the Medical Gazette,* of New York, an account of the experiments written by one of the witnesses:

"*The first successful application.*—On Friday, Oct. 7, by invitation, several medical gentlemen,† including the writer, met Prof. Bell at the house of Dr. Frank H. Hamilton, in this city, for the purpose of witnessing the practical application of his improved instrument.

"The first person subjected to experiment was General Calvin E. Pratt, judge of the supreme court of the State of New York,

* See Medical Gazette, Oct. 15, 1881, pp. 347–349.

† "The following are the names of the medical gentlemen who were present, each one of whom verified personally the results and declared his entire satisfaction with every experiment that was made: J. C. Hutchinson, J. G. Johnson and J. G. Allen, of Brooklyn; Elias Marsh, of Patterson, N. J.; Nathan Bozeman, J. H. Hunter, G. Durant, F. Delafield, L. Damainville, W. M. Chamberlain, J. H. Girdner, Frank H. Hamilton and E. J. Bermingham, of New York."

and who is now a resident of Brooklyn. General Pratt, at the battle of Gaines' Mills, June, 1862, this being the second day of the famous seven days' retreat across the peninsula, received a ball in his left cheek, which penetrated through the nares and was lodged in the right antrum. Its presence at this time was recognized by his surgical attendant, Dr. Damainville, and its exact position has been known from that day until this, it having given rise at times to much pain and suffering.

"General Pratt has been seen by Dr. Hamilton and Dr. Damainville occasionally from that time forward, and they have from time to time urged upon him the necessity of its removal. General Pratt, however, was anxious to know whether Prof. Bell's instrument would indicate its presence at the same point as declared by his surgeons.

"The results of the experiment were conclusive and entirely satisfactory to General Pratt, the response being heard distinctly, but rather feebly, by every person present in the room. The feebleness of the response was supposed to be due to the fact that, owing to its situation and the peculiar form of the instrument containing the induction coils, it was impossible to bring the center of its surface very near the site of the ball, the ball being situated very near the depression at the ala of the nose."

"The next patient was Col. B. F. Clayton, who received a wound at the battle of Cedar Mountain, Virginia, Aug. 9, 1862.

"The missile was supposed to be an Enfield rifle ball, and the wound was supposed to be mortal by the medical director of General Banks' staff and his assistants. The ball passed through the sternal end of the left clavicle, and was supposed to have lodged in the muscles under the superior angle of the corresponding scapula. The injury was followed by complete paralysis of the left arm, continuing for a period of six months; and his arm has never yet been completely restored to its normal condition. He suffers a great portion of his time from pains in the arm, shoulder, and portions of the back.

"Several small fragments of bone escaped through a fistulous orifice formed near the seat of the original wound.

"About eighteen months later an abscess opened on the front of the chest below the fifth rib and to the left of the sternum. Through this sinus his surgeon was able to carry a probe upward and backward toward the top of the shoulder several inches, and which sinus was supposed then to communicate with the seat of the ball on the back.

"Pleural adhesions were recognized by the medical attendants as having occurred in the upper part of the left thoracic cavity He has been troubled occasionally ever since the injury with cough, expectoration, and violent palpitations of the heart. A suspicion has even been entertained that the fistulous canal which remained open a period of eighteen months, and then became permanently closed, communicated with the bronchial tubes, but at no time was a suspicion entertained by him or his medical

attendants that the ball was not lodged in the back and there closely encysted.

"We are disposed to mention as an evidence of Col. Clayton's loyalty and faithfulness as a soldier that within six months of the receipt of the injury, and while the wound was still discharging pus and blood, he returned to active duty with his regiment and remained in the field until the close of the war.

"In the presence of the gentlemen assembled Col. Clayton exposed his chest, and Prof. Bell proceeded to move the coils across that portion of his back where the ball was supposed to be situated, the colonel indicating the point underneath the superior angle of the scapula as that which had been fixed upon by himself and all the surgeons who had examined him as its exact seat. Although being buried underneath the scapula, they had not been able to verify their diagnosis by the sense of touch. Repeated examinations were made over this region without any response both by Prof. Bell and several of the gentlemen who were present.

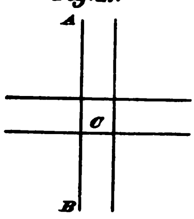
"The instrument was then moved in every direction across the back and shoulders with the same result. There was an evident feeling of disappointment on the part of Prof. Bell and all the gentlemen present, for no one entertained a doubt up to this moment that the situation of the ball was known and correctly stated by Col. Clayton.

"It was not until the lapse of half an hour, and a thorough examination on the part of Prof. Bell to determine if there was not some imperfection in the working of the apparatus, that it was suggested to move the instrument along the front of the chest.

"This was done by Prof. Bell, and immediately he exclaimed: 'I have found it.' And such was evidently the fact, as was verified by the personal examination through the telephone by every gentleman present. The response when the instrument was moved over the seat of the ball was loud and distinct, and left no room for doubt."

After all the visitors present had had the opportunity of verifying my discovery of the sonorous spot on the chest of Colonel Clayton, experiments were made to determine as accurately as possible the exact position of the ball.

Fig. 27.



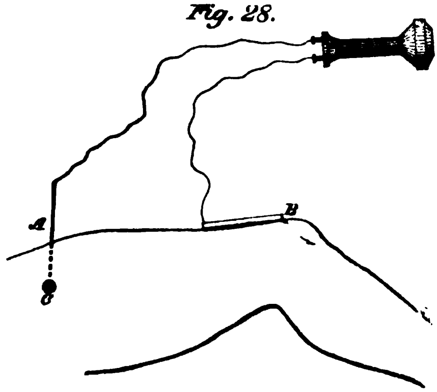
The exploring instrument (fig. 23) was first held over that part of the chest where the maximum sound was obtained. The instrument was then moved slowly toward the left until the sound could no longer be perceived. The position of the center of the instrument was noted, and a vertical line (A B, fig. 27) was drawn with ink upon the skin through that point. This line indicated the boundary of the sonorous area toward the left. The experi-

ment was then repeated by moving the instrument from the point of maximum sound toward the right, and also upward and downward, giving us the four boundary-lines shown in the diagram. (Fig. 27.) The bullet was thus located within a square, C, of about one inch.

"The exact situation of the ball," as described in the Medical Gazette, "was found to be within the thorax, probably in immediate contact with the inner surface of the ribs, the point being a little to the left of the sternum, between the third and fourth ribs, and two or three inches above the cicatrix on the front of the chest, where the sinus, long since closed, had evacuated itself, and in a direct line from this cicatrix toward the left shoulder, which indicated the line of the track of the original sinus."

Experiments with Needles.—During my absence from Washington and from all conveniences for experimenting personally with induction balance apparatus, I devised a method of verifying the indications of the induction balance and of ascertaining the exact depth at which a bullet lies beneath the surface. This method was communicated through Dr. Woodward to the surgeons in attendance on President Garfield, and it was made the subject of a special paper presented to the French Academy of Sciences, Nov. 7, 1881.

Fig. 28.



This method, although involving extremely slight pain, would ordinarily be used only as a preliminary to an operation for the extraction of a bullet. The arrangement is shown in fig. 28. A fine needle A is connected to one terminal of a telephone, and the other terminal makes contact with a plate B, preferably of the same material as that composing the needle. Place this metallic plate B against the surface of the patient's skin and thrust the needle into that portion of the body where the bullet is believed to be lodged. When the point of the needle

makes contact with the surface of the bullet C, a galvanic battery will be formed naturally within the body, the two poles of which are respectively the leaden bullet C and the metallic plate B. Under these circumstances a click will be heard from the telephone each time the bullet is touched by the needle. This has been verified by experiments upon bullets buried in a joint of meat The click, though feeble, is unmistakable.

I have no doubt that this method of exploration alone, without the induction balance, would prove of great service upon a field of battle where the employment of complicated apparatus is impossible. Mr. Thomas Gleason has recently communicated to me the particulars of an experiment he witnessed, in the course of which this method was tried upon a living subject. The surgeon who conducted the experiment was unable to obtain any response from the induction balance employed, although from certain indications apparent to the sense of touch he believed that the bullet was located in the part of the body submitted to experiment.

To verify his supposition a needle connected as above (fig. 28) was thrust into contact with the hard substance perceived, but no response was made by the telephone. The surgeon, however, believing that the bullet had been found, etherized his patient and proceeded with an operation, but discovered, when too late, that the bullet was not there.

Further modifications of Induction Balance.—I sailed for Europe early in October, 1881, and have had no opportunity since of continuing my researches until quite recently. While I was in Europe, however, Mr. Sumner Tainter devised a new kind of induction balance which deserves mention here. The results obtained with this apparatus in its present form (fig. 29) are not to be compared with those produced by the best instruments described above, but there are undoubtedly great possibilities of future development.

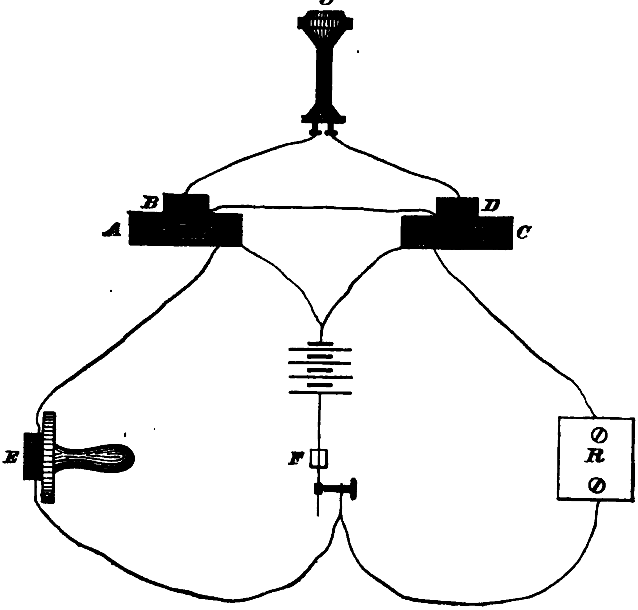
The important feature is that the exploring instrument E consists of *a single coil*, so that there is no possibility of any part of the explorer getting out of adjustment. All the adjustments are made upon the stationary part of the apparatus.

The current of the battery is divided between two equal circuits. One of the primary circuits contains the coil A and the exploring coil E, and the other circuit the coil C and a rheostat R. Coils A and C are exactly similar; and if the resistance introduced at R is equal to the resistance of the exploring coil E, an acoustic balance can be obtained by the adjustment of the secondary coils B D upon the primaries A C; but if the resistance introduced at R is different from that at E, Mr. Tainter states that no balance is possible.

When the apparatus is adjusted to silence the approach of a bullet to the coil E destroys the balance.

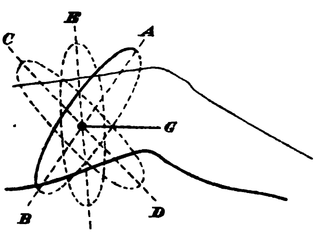
Although the great object of the researches that have been brought before you to-day has been to find that arrangement of balance which will detect a bullet at the greatest distance from the coils of the explorer, it must not be forgotten that in every case the instrument is more sensitive to the presence of a bullet placed *inside* the exploring coils than to one exterior to them. When, therefore, we seek the location of a bullet in one

Fig. 29.



of the limbs, it may be advisable to use an annular coil large enough to slip easily over the leg or arm, as the case may be.

Fig. 30.



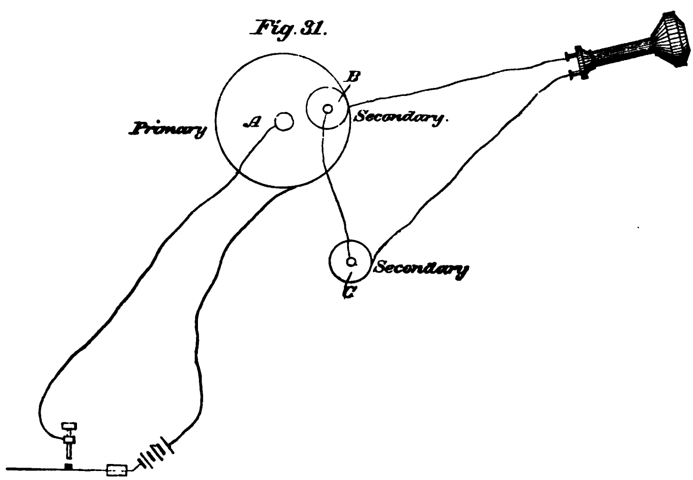
In Mr. Tainter's arrangement the exploring coil E (fig. 29) might simply be a large ring consisting of a number of convolutions of thick wire which could be slipped over the limb, or the ring might consist of two coils, forming one side of a Hughes' induction balance.

In either case the loudest sound will be produced when the bullet is in the plane of the ring, and its exact location should be deduced from three observations. Suppose, for instance, that with the ring inclined in a particular direction the maximum sound is obtained when the ring occu-

pies the position A B (fig. 30). We know then that the bullet is in that plane. Now incline the ring in some other direction and explore again. Let the position of maximum sound be now C D. We know then that the bullet is somewhere on the straight line formed by the intersection of the planes A B and C D. It is only necessary then to make a third observation with the apparatus so inclined that the plane of the ring cuts this straight line, for instance, the position E F. The point of intersection of the three planes G is then the exact point occupied by the bullet.

I shall conclude this paper by the description of an experiment made in Newport, R. I., a few days ago. The results are so unprecedented in my experience that I feel they cannot be received as implicitly reliable until the experiments have been repeated and verified.

Fig. 31.



I had arranged upon a table three coils (as shown in fig. 31). The large flat primary coil A was connected with a battery of four Bunsen elements and an interrupter, as shown, and the two small secondaries of fine wire, B C, were connected with a telephone.

The secondary B was moved about on the primary A until a position of silence was obtained. Upon bringing a leaden bullet near C the balance was disturbed and a distinct sound produced from the telephone. There is nothing very strange about this when we know that the distance between A and C was only 15 centimeters, so that C was well within the field of induction of A; but what did seem extraordinary was that the approach of the large steel blade of a penknife to the coil C produced no effect! The iron diaphragm of a hand telephone

brought close up to the coil C produced no sensible disturbance of the balance, whereas a small disk of lead produced quite a marked effect. A disk of copper the size of a telephone diaphragm also produced a good effect, but the sound was not sensibly louder than that due to the small leaden disk. A diaphragm of zinc occasioned a feeble but distinct disturbance of the balance. It is unfortunately the case that in all the forms of induction balance described above, lead gives the poorest effect of all metals. If people would only make their bullets of silver or iron there would be no difficulty in finding them in any part of the body! In the apparatus shown in fig. 31, however, it seems (unless subsequent experiments should reveal some fallacy) that we have an arrangement which is sensitive to lead and not to iron, or, at all events, which is more markedly influenced by lead than iron.

It is hardly necessary to state that when the coil C was removed to a considerable distance from the primary A, no effect was produced by the approach of metal to the coil C.

I have in this paper brought before you an outline of a labor of love pursued through many anxious days and sleepless nights. However imperfect or disappointing may be the results so far achieved, they are sufficiently encouraging to enable us to look forward with confidence to the attainment of still greater perfection.

I hope to continue these researches in the future; and certainly no man can have a higher incentive to renewed exertion than the hope of relieving suffering and saving life.

ART. IV.—*A Method for Determining the Rate of Tuning-forks;* by ALBERT A. MICHELSON.

THE tuning-fork is already employed to a great extent as a measurer of small intervals of time, and this use promises to become more extended as its advantages become more fully appreciated. Any method which will facilitate the operation of finding the rate, or increase its accuracy should therefore merit consideration.

The following plan appears to be open to fewer objections than any now in use, and its accuracy is limited only by the accuracy of the pendulum.

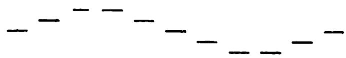
The fork to be rated, for example an Ut_2 making about 128 double vibrations per second, is compared with an Ut_2 kept in vibration by electro-magnets and which shall be designated EUt_2, and this is compared directly with the seconds pendulum, and then the two forks are once more compared, to make certain that EUt_2 has not changed in the interval. Thus Ut_2 is

determined. The whole operation may be performed in less than ten minutes.

To determine the rate of EUt_2 we will suppose that this is within a small fraction of a whole number of vibrations per second, and that this whole number is known; say 128 v. s. A mirror is attached to one prong of EUt_2 and in front of this, and at a distance of two or three feet, is placed a Geissler tube. This last is illuminated once every second. The tube itself is continuously illuminated and its image in the mirror presents the appearance of a broad band with well-defined edges. Against this the narrow flash is projected.

Evidently if EUt_2 makes an exact whole number of vibrations per second, then this flash will always find the fork in the same phase of vibration, and consequently its image will always appear at the same part of the band. If, however, the fork makes, say 128·1 v. s., then it will occupy successively the positions

0 1 2 3 4 5 6 7 8 9 10



That is, there would be ten flashes between the positions (0) and (10). If, therefore, ten flashes occur in one "period" then the whole number 128 is to be increased (or diminished) by one-tenth; and in general if a flashes occur in one period then EUt_2 makes $128 \pm \frac{1}{a}$ vibrations per second.

Since EUt_2 vibrates continuously the number of periods which may be counted is unlimited, hence a can be found with any desired degree of accuracy.

It was found that the chief difficulty in executing this plan lay in the imperfections of the break-circuit. If thereby the seconds intervals differed as much as 0·002 seconds, then the operation would be impracticable, on account of the irregularities in the position of the flashes. A great many break-circuits were tried, and the one which was finally adopted as being the most reliable and giving the least trouble was the "mercury globule." Even this, however, in its usual form was unsatisfactory. A great improvement was effected by narrowing the globule in the direction of the swing of the pendulum, by placing it in a small tube whose upper end was flattened. If the current from a "bi-chromate" cell is interrupted by this break-circuit the mercury oxidizes rapidly, and the flashes (given by a small induction coil through the Geissler tube) become irregular.

To obviate this difficulty, the circuit of a "gravity" battery was interrupted, and this worked a relay, which in turn inter-

rupted the circuit of the induction coil. The results thus obtained left nothing to be desired.

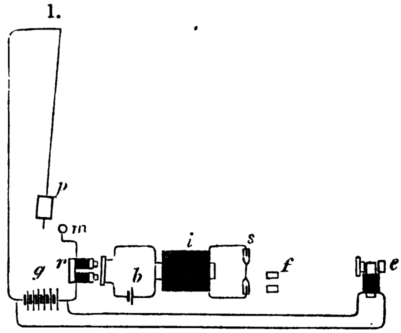
In order that the rate of EUt_2 remain constant, it is necessary that the current passing through its electro-magnets be constant. Hence the necessity for constant batteries, which, however, have a comparatively great resistance. Several might be joined in parallel circuit, but it was found that much better results were obtained by using six "gravity" cells in series, and using fine wire magnets. Such a battery will keep the fork in vibration indefinitely with but little alteration in its rate except that due to variations in temperature.

In comparing the forks a convenient plan is to weight the EUt_2, so that it gives with the fork to be rated about 9 beats in 10 seconds, and then to time the "coincidences" between the beats and the ticks of the pendulum. By this means the comparison can be much more accurately determined than by counting the beats for sixty seconds. This may also be done by the optical method. It was found that the "gravity" battery which kept the EUt_2 in vibration could serve at the same time to work the relay.

The whole arrangement is shown in fig. 1, in which, for clearness, all the parts to the right of *i* have been shown in the plane of the drawing, instead of at right angles.

1.

p, pendulum.
m, mercury globule.
g, gravity battery.
r, relay.
b, bichromate battery.
i, induction coil.
s, Geissler tube.
f, fork to be rated.
e, "electric" fork.



In practice only the even flashes are counted, the odd ones being disregarded. Consequently, if a be the number of these per period, n, the rate of the fork, and $2N$, the whole number nearest to $2n$, then $n = N \pm \frac{1}{2a}$. To determine which sign is to be used, EUt_2 is weighted by a very small piece of wax. If a is greater than before, the sign is $+$; if a is less, the sign is $-$.

The electric fork may be dispensed with entirely by the following method. The fork to be rated is placed vertical, so that one edge is in the focus of a microscope provided with

cross-hairs. Behind the fork the Geissler tube is placed horizontal. The appearances observed in the microscope at each flash would then be as follow:—

From these we can deduce the rate as before.

This method would probably give results almost if not quite as accurate as the preceding, and has the advantage of being more direct. The nearest whole number may be found by comparison with one of König's standards, or by the following method.

The fork is, in turn, compared with two pendulums, whose times of vibration are t_1 and t_2, $t_1 - t_2$ being small.

Let n_1 = number of vibrations of the fork in time t_1.

Let n_2 = number of vibrations of the fork in time t_2.

n_1 and n_2 differing from a whole number by less than a small fraction, e_1.

Let a_1 = number of beats of pendulum (1) per period $= \frac{1}{c_1}$.

Let a_2 = number of beats of pendulum (2) per period $= \frac{1}{c_2}$.

c_1 and c_2 being small fractions less then e_2.

Let N_1 = whole number nearest to n_1.

Let N_2 = whole number nearest to n_2.

Then
$$n_1 + c_1 = N_1$$
$$n_2 + c_2 = N_2$$
$$n_1 - n_2 + c_1 - c_2 = N_1 - N_2 = M, \text{ a whole number.}$$
$$n_1 - n_2 + c_1 - c_2 \text{ is less than } 2(e_1 + e_2).$$

If, therefore, $2(e_1 + e_2)$ is numerically less than $\frac{1}{2}$ then $M = 0$, whence $N_1 = N_2 = N$.

$$\frac{n_1}{n_2} = \frac{N - c_1}{N - c_2} = \frac{t_1}{t_2} \text{ and } N = \frac{c_1 t_2 - c_2 t_1}{t_2 - t_1}.$$

Eight determinations of the rate of an Ut_2 fork, made by the preceding method gave the following results:

Temp. Fahr.	v. s.	v. s. at 60° F.	Diff. from mean.
54·0°	128·134	128·090	+0·003
56·3	128·114	128·087	0·000
58·0	128·102	128·087	0·000
60·0	128·090	128·090	+0·003
62·2	128·077	128·093	+0·006
63·0	128·060	128·082	−0·005
64·5	128·050	128·083	−0·004
73·5	127·984	128·084	−0·003

ART. V.—*On the Relations of the Menevian Argillites and associated Rocks at Braintree and vicinity, in Massachusetts;* by W. W. DODGE.—With a map.

THE well known syenite of Quincy, Massachusetts, occupies an area a mile and three quarters wide with its northern and southern sides running approximately east and west,—a little north of east, and south of west. It forms two principal east-westerly lines of steep sided hills, or ridges cut across by glaciation. From the base of these, the rock extends to some distance on the more level ground. From Quincy, the rock extends into Milton on the west, and a short distance into Braintree on the south.

The northern of the two lines of hills ends near the Old Colony Railroad on the east, but in the southern there is a detached eminence, known as Penn's Hill, east of the railroad. This hill is separated from those to the westward by a valley half a mile broad, in which the local rock, whatever its character, is concealed by stratified gravel and sand there forming a plain about forty feet above high tide, in which the railroad runs, and through which Town River flows from Braintree to its outlet east of Quincy (Center) village.

Some of the several hills may represent independent outflows (the syenite is an eruptive rock), but the valley referred to is in its present shape a channel of erosion and glaciation.

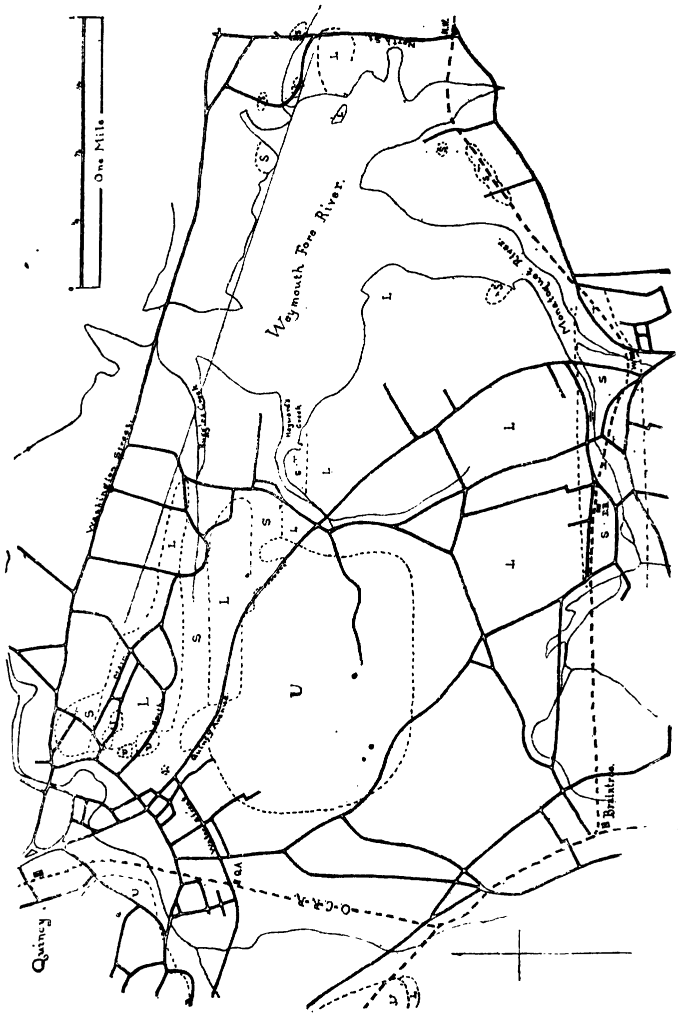
North, east and south of Penn's Hill, between the Cohasset Branch Railroad and Washington Street (the road from Quincy to North Weymouth and Hingham), in Quincy and Braintree, the most abundant surface rock is a fine-grained syenite, which underlies the coarse Quincy syenite, and is entirely distinct from it. The fact that the two are not merely varieties of the same rock seems to have been overlooked. For the purposes of the following account of the two eruptives, the older will be called the Braintree syenite.

The expanse of the older rock is interrupted by bands of argillite, in which at one point occur *Paradoxides* and other fossils.

Stratified Rocks (S on the accompanying map.)—Concerning the stratified deposits at the south shore of Boston Harbor, only such details need be here presented as seem to have significance concerning the relations of the strata and their disposition with reference to older and newer rocks.

Of the stratified rocks in an anticlinal fold bordering on the north the coarser syenite in Quincy, the sandstones and slates on the north side of the narrow conglomerate axis measure,

so far as exposed, 288 feet west of the railroad, 312 at Hough's Neck, the strata being nearly vertical. The conglomerate as seen on the south side of Hough's Neck is penetrated by various eruptives, feldspathic as well as pyroxenic.



THE MENEVIAN OF BRAINTREE, MASSACHUSETTS, AND ASSOCIATED ROCKS. BY W. W. DODGE, 1882.

S = Argillites; L = Lower Syenite; U = Upper Syenite; Q = Quarries.

The coarse-grained, bright-colored syenites in Hingham and the adjoining towns (frequently micaceous), and in Weston, have a strong resemblance to each other, so far as regards the body of the rock. That in Weston is porphyritic with large simply-twinned feldspar crystals; Mr. Crosby has noted the occurrence of the same peculiarity at one place in Hingham.

An area of syenite west of the southern part of Hingham Harbor is nearly surrounded by conglomerate, which like the Roxbury conglomerate contains frequent pebbles of distinctly stratified rock. Pebbles also occur which evidently had their sources in the local representative of what has been named "Shawmut amygdaloid," found in place, for example, north and west of Squirrel Hill, as the Roxbury conglomerate has numerous pebbles of the similar rock which occupies a large area and several small spots in Newton and Needham. The conglomerate and syenite are found together eastward as far as the seashore. South of the Cohasset Branch Railroad, between the Hingham and West Hingham stations, are about 700 feet of conglomerate, sandstone and slate dipping southerly 55°, with much intrusive rock of various character, often amygdaloidal, in one place coarsely porphyritic and containing well-developed crystals of magnetite of good size. Beds of sandstone and slate bend around the western side of the conglomerate and extend northeasterly along the west shore of the town, showing at Beal's Cove a thickness of about 500 feet, there standing nearly vertical, the highest beds (above a dike) inverted to an easterly dip. North and east of Hewitt's Cove are large masses of diabase. In this rock, at one point near the beach at the head of the Cove, calcite has replaced large crystals of triclinic feldspar.

An anticlinal of slates more than a mile long, 1100 feet wide, occupies the valley of Monatoquot River in Braintree, and extends into Weymouth. The strike is about east and west. The strata on the north side dip at 70°, so far as observed, giving a thickness of about 475 feet; on the south the dip is occasionally much lower. The southern half of the fold is overlaid in Weymouth at its eastern end by a light-colored eruptive, chiefly quartzo-feldspathic; and this is cut and capped by diabase, which may also be seen in contact with the slate on both sides of Washington street at the corner of Commercial, in Braintree. At its western end and to some extent on its southern margin, this band of slate passes under hills of drift. Westward, in the northern part of Braintree, the surface configuration shows it probable that the slates continue beneath the surface in that direction.

On the western side of Weymouth Fore River, in the extreme eastern part of Braintree, and along, and also about two hundred feet north of, the railroad west of North Weymouth station, are slates. In the railroad cut (where the strike is about east-west) they may be seen bending over from 85°, the usual dip, to 15° under the masses of eruptive rock at the south side of the railroad. This last named rock, while quite unlike the typical form of the Braintree syenite, resembles a

variety of it which occurs on the north side of the quarry lane leading from Hayward's Creek toward Penn's Hill.

At the trilobite quarry, south of Hayward's Creek, the strike is east-west, the dip 65° south. Passing westward to the other side of the creek, the Braintree syenite is found at the surface, and this in turn disappears, farther in the same direction, under the Quincy syenite, while north of these the slates appear with the same strike, making the full width of the band about 1000 feet, from which the thickness may be estimated at 450 feet.

The next band, more than an eighth of a mile northward, lying between Quincy avenue and South street, is more than 400 feet wide, and over half a mile long. The strata of this fold have high dip; their strike is substantially east and west.

Half a mile east-southeast of Quincy railroad station are 450 feet of slates dipping southward, and with strike N. 75° W. These slates, extending S. 75° E. beneath the surface, would lie along the northeasterly side of the adjoining area of Braintree syenite. In Weymouth, outcrops are found half a mile north of the railroad, near Pearl street on both sides of North street, extending for nearly half a mile, 500 feet wide, with Braintree syenite immediately south of them. At both of these places the slate has frequent large oval cavities partially filled with epidote, which are sometimes irregularly scattered, sometimes distributed along lines of decoloration (perhaps also intrusion) parallel to the stratification plane. Diabase is found with the slate in Quincy (east side of Union street), where its presence, securing immunity from glaciation, accounts for the abundant exposures of the various rocks to the southward. The rocks, not rising to great elevation, are somewhat masked at Quincy Point and North Weymouth by the gravel and sand plain which has been already referred to in its extension west of Penn's Hill. The North Weymouth beds lie in the direction of the strike of the fossiliferous beds at Hayward's Creek, and would naturally be regarded as the eastward continuation of these. Their own strike at North street is N. 80° W., and although nearer Fore River it is west, their westward extension may be parallel to Washington street. It is not improbable, however, that the northern surface limit of the most northerly area of Braintree syenite is determined by glaciation rather than by the actual extension of the rock, and that the slates north of this have, except locally, the more common east and west direction.

There seems to be no reason to doubt that the argillites of all these folds are of the same age. Their maximum thickness appears to be not far from 500 feet. The relation of the argillites and the Hingham conglomerates can be more safely deter-

mined after examination of the relation of the Weymouth and Hingham syenites.

Braintree Syenite (L on the map).—Over a region extending a mile and three-quarters north from the Monatoquot Valley, this rock occupies the spaces between the bands of slate described. Abutting against the steep sides of the folds, it shows straight and prolonged lines of junction. The two rocks may usually be found exposed within a few feet of each other along the contact line, but the actual contact is most readily observed at the southerly margin of the Ruggles' Creek strip of slates. Near the contact, the syenite becomes compact and black or dark brown, porphyritic with occasional crystals imbedded in the ground mass but distinguishable on fresh fractures by the luster of the cleavage planes. This form is found on a face of rock bordering a narrow valley which crosses Main street east of Union, in Quincy (not shown on the map); the presence of drift-covered slates in this channel through the syenite may be safely inferred, although no outcrop can be detected. The syenite is generally light or dull brown, but varies to yellow and to speckled gray. Near dikes of diabase, the rock is blackened, assuming a very different appearance from its usual condition. The feldspar crystals in the typical form of the rock are often three-eighths of an inch long, but are enclosed in a finer ground mass. Quartz is abundant, but in very minute grains, often undistinguishable with the unaided eye. The hornblende is in places well crystallized and plentiful, usually not conspicuous, sometimes is much decomposed.

This rock occupies but a small area in Weymouth, unless rocks south of the railroad are to be included with it; its widest expanse is in Braintree, where it spreads from Weymouth Fore River to the valley west of Penn's Hill. It probably extends southward beyond the limits of the map. It never rises to as great elevation as does the Quincy syenite. West of the Old Colony Railroad, it forms the southern side of a small hill near the Quincy-Braintree line, west of the Granite Branch Railroad. Southwest of Pine Hill, it occurs on Willard street near the town boundary, but northward along the West Quincy valley it does not appear.

Quincy Syenite (U on the map).—The quarries at Pine Hill show this rock to hold inclusions of two kinds,—one a light colored, fine-grained quartzose syenite with white feldspar, the other a porphyritic diabase. The small hill east of Pine Hill, above referred to as made up in part of the lower syenite, is capped with this rock. Its northeast side is composed of it, and there a glaciated ledge near the West Quincy Branch Railroad shows the coarse syenite to be crowded with inclusions of diabase (?), fine grained, black, porphyritic and highly mag-

netic, sometimes pyritiferous. The fragments vary in size from a few inches in longest diameter, to many feet in length. Coarse syenite south of the Monatoquot slates holds inclusions of fine grained syenite.

Penn's Hill is composed chiefly of the Quincy syenite, although based on the older eruptive. The principal area covered by this newer rock at that place is a mile in longest diameter; at various points about its edge, the rock occurs in patches alternating at the surface with exposures of the underlying syenite. It is found at the top of a hillock two hundred yards north of East Braintree station, apparently protected against removal by glaciation by the presence of diabase.

No modification in the Quincy syenite where it is in contact with the underlying syenite has been observed. The older rock may have been yet hot when the more recent covered it. No inclusions of the older in the newer have been identified.

The great abundance of quartz in conspicuous lumps in the upper rock makes it easily distinguishable from the older eruptive. On weathered surfaces the former is rough with these lumps, even when heavily lichened, the latter smooth and of a general yellow or brown color. The variety of the newer rock most quarried is blue, but the brown is also used.

Mr. Wadsworth has published* the result of a microscopic examination of this syenite, both the typical form and the "bands" in it. One of these dikes (?), exposed at a quarry in Milton near the Quincy line, is five feet wide, with a direction E. 2° N., and inclination or dip to the northward, 25°. It meets the rock on each side with a distinct junction. It is finer grained than the adjoining rock, of similar color in the central portion, while in the outer inch or two it is very much lighter colored and in the next two or three inches inward, of intermediate tint.

The rough woodland of western Quincy is much less favorable for accurate examination of the distribution of the rocks, than the cleared, settled and carefully mapped parts of the town. The coarse syenite lies in great hill ranges, and the massive dark gray argillites lying upon the steep hill sides are much covered by fallen debris from the crests of the hills. The slates on the east side of Randolph Turnpike have a strike N. 70°–75° E., and are there exposed for a width of about ninety feet.

Examination of the accompanying map shows that two slate bands pass under the Penn's Hill syenite on its eastern border. The most that can be said as to the identity of the strata that appear from under these wide-spreading masses of eruptive rock at different points is that their similarity of char-

* Proceedings of the Boston Society of Natural History, vol. xix, p. 309.

acter makes it extremely probable that there is no break in their continuity in the prevalent line of strike.

The relation between the Quincy syenite and the adjoining Blue Hill region of southwestern Quincy and southern Milton, in which the rocks are in part at least of sedimentary origin, remains to be determined. The strata at this last named locality may well be examined in connection with the highly altered stratified rocks with associated eruptives at Mattapan in Boston and at northern Hingham.

Diabase.—Dikes are doubtless of frequent occurrence throughout the area discussed in this paper, but no search has been made for them. South of Quincy avenue, one ten or fifteen feet thick runs east and west near the junction of the coarse and fine syenites; and nearly in the line of this dike, northeast of the avenue, the Braintree syenite is cut by a dike one or two inches thick. The dike at the Sheldon & Co. quarry west of West Quincy runs N. 60° W., this like the preceding having a northerly dip. The syenite is injured as a quarry stone by the intrusion of these dikes, but no particular visible change of its character seems to be produced.

From what has been above stated, it will be seen that there are eruptives older than the conglomerates of this region and others younger; also eruptives both older and younger than the Quincy syenite; the dikes which cut the latter have the east-westerly direction (prevalent in Hingham and Weymouth south of the region under consideration) which belongs to those dikes cut across by a system of north-southerly dikes in some places in the vicinity of Boston.

Penn's Hill is strewn with bowlders of stratified rock. A small circle on the map, in the southwestern part of the largest area of Quincy syenite, marks the position of a tower at the top of the hill. The quarry, quarter of a mile or more east of this, is at the base of the hill.

ART. VI.—*Observations of the Transit of Venus made at the Washburn Observatory, Madison, Wisconsin,* 1882, *December* 5–6; by EDWARD S. HOLDEN.

THE Transit was observed at the Washburn Observatory by two persons independently, viz: by myself, using the 15½-inch Clark equatorial, with the aperture cut down to 6 inches; and by Mr. G. C. Comstock, assistant in the Observatory, using the 6-inch Clark equatorial which formerly belonged to Mr. S. W. Burnham. We were assisted by two of my students, Messrs. Conradson and Pennock. It is hardly necessary to say that both instruments are of the highest excellence.

Preparations for the Transit.—The large telescope had its aperture reduced as described. A positive eye-piece magnifying 195 times, with a field of 11′ 42″, was fitted to one of Clark's reflecting solar eye-pieces. This was carefully focused on the sun and on stars on several occasions, and the tube was set at a mean reading of the focussing-scale.

Marks were put on the tubes by which the positions were recoverable at any time. A pair of cross-wires (platinum) was inserted in the eye-piece and the sun's light was reduced by a Steinheil "moderating-glass." An easy geometrical construction assured me of the exact point of first contact.

The 6-inch telescope was also provided with a Clark's solar eye-piece, to which a positive eye-piece magnifying 176 times was fitted. A pair of crossed platinum wires was also fixed in front of this eye-piece. The focal point and the point of first contact were determined independently by Mr. Comstock and myself.

All the preliminary adjustments remained constant till after the Transit. The time was determined by observations of twenty stars on the nights of December 4th, 5th and 7th. All time-pieces were referred to the Hohwû sidereal clock. The Washington time-signals were received on December 5th and 6th, and it may be mentioned that the resulting longitude of the Washburn Observatory differs from the adopted longitude by considerably less than one-tenth of a second of time. All sidereal times here given are local: all mean times are Chicago mean times, and are $7^m\ 11^s{\cdot}11$ later than local mean times.

Geographical positions.—The position of the large telescope is as follows:

Longitude W. from Washington, $0^h\ 49^m\ 25^s{\cdot}78$. Latitude $+43°\ 4'\ 36''{\cdot}8$.

The position of the small telescope is as follows:

Longitude W. from Washington, $0^h\ 49^m\ 25^s{\cdot}60$. Latitude $+43°\ 4'\ 37''{\cdot}5$.

Observations.—The following is a transcript from my observing-book: "Dome opened $19^h\ 30^m$. $19^h\ 45^m$. Image of sun extremely unsteady. [The times are noted on sidereal chronometer S.]

"I. $13^h\ 8^m\ 0^s \pm$. Through clouds and haze: sun unsteady, and the lightest part of the Steinheil wedge used. I could not have observed with the usual shade-glass. Time uncertain by 5^s or perhaps 10^s, though I think not more than 5^s. Venus entered exactly at the point where wires were set. At $20^h\ 27^m$ (Chicago m. t.) the whole disc of Venus is seen, and a little ring of light outside it. This was not specially looked for, but is first seen now.

"II. (*a*) $13^{h}\ 26^{m}\ 59^{s}$. By prolonging the contour of Venus, mentally, this is the time of geometric contact, though the limbs are connected. (*b*) $13^{h}\ 27^{m}\ 29^{s}$. The contour is inside, but the connection still persists. (*c*) $13^{h}\ 27^{m}\ 47^{s}$. Same as before. (*d*) $13^{h}\ 28^{m}\ 0^{s}$. The first instant that the cusps of the sun meet round Venus. Air extremely unsteady." Everything preceding this was written out before leaving the dome. The minute and second of I. were noted by myself and they are correctly recorded. The minute of II. was noted by Mr. Conradson and it may need a correction of $+1^{m}$. This affects Mr. Comstock's observations of II. also.

Chronometer Comparisons.

S = (Chronometer)	= M = mean time clock keeping Chicago time.
$12^{h}\ 45^{m}\ 25^{s}$	$= 19^{h}\ 51^{m}\ 57^{s}$
13 38 50	= 20 45 13
H = (Sidereal clock)	= M (Mean Time clock)
$12^{h}\ 44^{m}\ 29^{s}$	$= 19^{h}\ 48^{m}\ 0^{s}$
13 44 50	= 20 48 11

On these observations I have to make the following remarks. (*a*) I should take to be the time of first contact. (*b*, *c*) the ligature persists, but in both of these phases the contour of Venus prolonged by the eye lies inside the limb of the sun, especially so in (*c*). (*d*) This is clearly far past II, but it is the first time that the cusps of the sun meet, and even then they do not persist until about 11^{s} later. Contacts III and IV were lost. A snow storm set in about 22^{h}. The sun was not visible at its transit over the meridian. I was particularly surprised at the persistance of the black-drop, which I attribute to the bad state of the atmosphere. Certainly the objective, eye-piece and all the apparatus were in perfect adjustment. It could not have been better. The reductions of these observations are given below.

With regard to the work of Mr. Comstock, I copy from a MS. report which he has handed to me, what relates to the contacts. [The times were noted on sidereal chronometer B.]

"I. $1^{h}\ 9^{m}\ 1^{s}{\cdot}0$. The planet came about where it was expected. The observation is perhaps 4 or 5 seconds late. The sun's limb was quite obscure and the observation difficult. I think that I saw the body of the planet outside the sun as soon as I saw the nick.

"II. 33^{s}; 44^{s}; 55^{s}; 0^{s}. At 33^{s}, a bright line of light shot across from cusp to cusp. At 44^{s}, another line, equally thin, was seen. At 55^{s}, cusps seemed to meet for the first time. At 0^{s}, second contact is certainly past."

Chronometer Comparisons.

H.	12^h	54^m	$30^s{\cdot}0$	= B.	12^h	52^m	$10^s{\cdot}95$
H.	13	35	15·0	= B.	13	32	56·1
H.	13	44	54·0	= M.	20	48	15·0

The corrections to the time-pieces are tabulated below.

	At I.	At II.
ΔH	$= -\ 2^m\ 43^s{\cdot}56$	$= -\ 2^m\ 43^s{\cdot}55$
ΔS	$= +\ 0^m\ 18^s{\cdot}09$	$= +\ 0^m\ 17^s{\cdot}96$
ΔB	$= -\ 0^m\ 24^s{\cdot}51$	$= -\ 0^m\ 24^s{\cdot}65$

Whence the observed times are (*Chicago* mean times):

Holden.				Comstock.			
I.	20^h	14^m	$28^s{\cdot}2$	I.	20^h	14^m	$46^s{\cdot}6$
II. (*a*)	20	33	24·0	II. (*a'*)	20	33	15·4
(*b*)	20	33	53·9	(*b'*)	20	33	26·4
(*c*)	20	34	11·8	(*c'*)	20	33	37·3
(*d*)	20	34	24·8	(*d'*)	20	33	42·3

The predicted times of I were—

Nautical Almanac	20^h	13^m	10^s	Chicago mean time.
Berliner Jahrbuch		12	20	"
Almanaque Nautico		12	32	"

The predicted times of II were—

Nautical Almanac	20^h	33^m	51^s	Chicago mean time.
Berliner Jahrbuch		32	58	"
Almanaque Nautico		33	9	"

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On an improved Apparatus for Gas Analysis.*—Geppert has described some improvements which he has made in the Bunsen eudiometer and its surroundings in order to lessen the work of reduction. The eudiometer itself, which is 80^{cm} in length, is prolonged 40^{cm} above its closed end by a tube of the same diameter open at top, the whole being supported by a Cardan's suspension attached to a wire. The mouth of the eudiometer opens beneath mercury contained in a cylindrical glass vessel. In the same vessel the open end of a barometer tube dips, the upper and closed end being enlarged to a diameter of 2^{cm}. Over the eudiometer and barometer is placed a glass cylinder 110^{cm} high, 9^{cm} in diameter and $\frac{1}{2}^{cm}$ thick, open at both ends. Its lower end is immersed in mercury contained in a glass battery jar 14^{cm} high and 12^{cm} in diameter. The bottom of this jar is covered to a depth of $1{\cdot}5^{cm}$ with a resinous cement, in which the inside vessel of mercury is fastened, The eudiometer and barometer tubes

being filled with mercury and inverted in the proper vessel, the cylinder is placed over the whole and filled with water. This water enters the prolongation of the eudiometer tube through a lateral opening. By means of a tube passing up through the bottom of the battery jar, the eudiometer tube may be filled with gas, which takes at once the temperature of the water. The levels of the mercury in the eudiometer and in the barometer are read off with a cathetometer. The difference gives the tension of the gas, and the former reading the volume of the gas. By moistening the interior of the barometer bulb, the correction for moisture becomes unnecessary. The water column maintains the temperature uniform and obviates the long standing required when the eudiometer is in the air. The barometer being affected equally with the eudiometer by the water column, no separate correction is needed for this. By means of the tube opening beneath the mouth of the eudiometer, not only may gases be introduced but also liquids for absorption. An oxygen determination by explosion with hydrogen—the eudiometer being held firmly against a rubber pad at the bottom of the mercury vessel—requires only 15 minutes with this apparatus and an analysis of blood-gases only $\frac{3}{4}$ of an hour.—*Ber. Berl. Chem. Ges.*, xv, 2403, Nov., 1882. G. F. B.

2. *On the Determination of Sulphur in Coal Gas.*—An improved form of apparatus for the determination of sulphur in coal gas has been devised by KNUBLAUCH. The gas is collected in a metallic holder of 20 liters capacity so arranged that it may be filled either with gas or water at pleasure, and serving to measure the quantity. The gas passes from the holder into a combustion tube 9 or 10^{mm} in diameter and 30^{cm} long, in which is a loose plug of platinized asbestus. The end of this tube is drawn out, slightly bent at right angles, and ground in to the upper end of the tube of an absorption bottle. From the lateral tubulure of this a tube passes connecting with a second absorption bottle. Then comes a series of bulbs and finally a wash bottle connected with a meter and a Bunsen pump. By the side of the tube which conveys the gas into the combustion tube is a second tube serving for the simultaneous admission of purified air, drawn in by aspiration. In making an experiment, the holder is filled with gas, the water turned on, and the gas, together with 5 or 6 times its volume of air, is drawn into the combustion tube and over the heated asbestus. The H_2SO_4 and SO_2 from the combustion of the sulphur are absorbed in a solution of potassium carbonate, ten grains to the liter, contained in the absorption flasks. The amount of admixed air is determined from the combustion products passing through the meter. The contents of the absorption bottles are treated with permanganate to oxidize any SO_2, decolorized with oxalic acid, and precipitated with barium chloride; 10 c.c. of a solution containing 7 grams to the liter. The operation requires about an hour and the results vary only 0·2 to 0·3 gram of sulphur in 10,000 liters of gas.—*Ber. Berl. Chem. Ges.*, xv, 2397, Nov., 1882. G. F. B.

3. *On the direct Formation of Zinc Sulphide.*—For showing the action of sulphur on metals, copper foil or iron filings are generally employed. SCHWARZ has called attention to the much more brilliant phenomena attending the use of zinc. When two parts of ordinary zinc dust are intimately mixed by sifting, with one part of washed flowers of sulphur, the resulting mass is readily inflamed with a match, burning like gunpowder with a vivid brilliant flame somewhat greenish in color, and leaving only a slight yellowish-white residue of zinc sulphide. The author was led to the experiment by having an explosion as the result of heating zinc and sulphur in a porcelain crucible in the endeavor to prepare zinc sulphide in the dry way. Indeed, he finds that the above mixture may be inflamed by the blow of a hammer. Tried in the ordinary way in a test-mortar, two grams of the mixed zinc and sulphur produced as much explosive effect as half a gram of gunpowder. This ready union of zinc with sulphur suggested further experiments. If carbon disulphide vapor be passed over zinc dust gently heated, the zinc glows as soon as the CS_2 vapor reaches it, yielding zinc sulphide and depositing carbon in the form of lamp-black; forming an interesting lecture experiment. The combination of carbon and hydrogen in the nascent state is effected by passing hydrogen sulphide through CS_2 and then over moderately heated zinc dust. The products are passed, first through a wash-bottle containing KOH to remove the excess of H_2S and then into a gasometer. The gas collected burns with a feebly luminous flame yielding CO_2. On analysis it gave 70 per cent of methane CH_4 and 30 per cent. hydrogen. If in this experiment, H_2S is replaced by NH_3, the reaction takes place according to the equation: $CS_2+(NH_3)_2+Zn_2=(ZnS)_2+CNNH_4+H_2$, forming ammonium cyanide. This desulphuring action of zinc is an important one in organic transformations. Thiocarbanilide treated in this way gives aniline and benzonitrile; thiocarbtoluidide, the paratoluidine from which it was made and tolunitrile; allyl sulphocyanide gave allyl cyanide, and this with alcoholic potash gave ammonia and crotonic acid.—*Ber. Berl. Chem. Ges.*, xv, 2505, Nov., 1882. G. F. B.

4. *Electromotive Force.*—It has been maintained by Exner that there is no known case of chemical action without the development of electricity and also of the development of electricity without chemical action. BRAUN controverts this conclusion and repeats Exner's results. The latter employed a cell with zinc and platinum as elements, with iodine or bromine as the liquid. Notwithstanding the fact that iodine and bromine are elements and cannot therefore be electrolytes, this cell gives with an electrometer a difference of potential and in a closed circuit an electrical current. Exner believes that the cause of this current is to be sought in chemical action. According to his statement, wherever a chemical change results in a difference of potential, an electrical current results whether the different metals are immersed in an electrolyte or not, as long as the liquid can conduct electricity.

Braun endeavors to show that Exner reasons in a circle, since as soon as chemical action enters, the combination ceases to consist of elements, and it is necessary to show that the existing combinations are not conducting electrolytes. Braun shows that Exner did not take sufficient precautions to ensure the purity of the iodine and bromine which were employed, and also to prevent the presence and disturbing influence of the aqueous vapor of the air. He concludes from the repetition of Exner's results that the conclusions of the latter are untenable. There are numerous cases in which we have a development of electricity without chemical action, and also strong chemical action without the development of electricity. A zinc and a copper plate in contact give a difference of potential; by their mutual attraction they can give out a certain amount of work. Their action can be represented by a piece of iron and an attracting permanent magnet; the removal of the iron requires work to be done and the attraction of the iron by the magnet affords work. This action of a permanent magnet on iron, in the case of dynamo machines, can play as great a function as the contact of Zn | Cu in a battery. Exner asserts that the electricity apparently due to contact is at the cost of the heat of oxidization. Braun says that this is equivalent to maintaining *à priori* that the permanent magnet affords heat at the expense of some process of oxidization.

Having criticized Exner's results, Braun shows how important the study of electromotive force is to the subject of thermal chemistry. A part of the matter in the series of difference of potential persists in that order in which the materials dispossess each other. While taking into account the heat of combination and Berthelot's principle of maximum work this ought not to happen; for instance, mercury is displaced by copper in Hg_2Cl_2 notwithstanding the greater heat of combination of mercury. The affinity of platinum and gold on the one side and copper and silver on the other toward chlorine stands in no relation to the thermal development (*Wärmetonungen*). From purely *à priori* considerations Braun thinks that it is possible that chemical changes are dependent upon the thermal condition; he, however, is convinced that the fitness for mechanical work of a chemical process determines the chemical change. If, for instance, the entire thermal development due to a process is zero, still exchanges can take place in which that combination results which is more stable in reference to heat. The direct chemical process which goes on without the development of electricity results in lowering the fitness for work of the entire matter. For Berthelot's principle, which can be entitled the principle of maximum development of heat, Braun substitutes the principle of maximum fitness for work. Berthelot's principle would then be a special case of the last, and would apply at the absolute zero of temperature, and the departures from his principle would be greater the nearer the temperature at which the investigation is conducted approaches to the dissociation temperature of the materials employed.—*Ann. der Physik und Chemie*, No. 12, 1882, pp. 593–642. J. T.

5. *Objections to Siemens' New Theory of the Sun.*—M. FAYE has made a calculation of the amount of matter which would be added to the solar system by Dr. Siemens' hypothesis. This matter would be attracted to the sun and stars and would increase their mass. A liter of air containing the requisite amount of aqueous vapor weighs at least 1 gram at ordinary pressure. At a pressure of $\frac{1}{2000}$ which is required by Dr. Siemens, this will amount to 0·0005 grams, and a cubic meter will weigh 0·0005 kilograms. If we consider the solar system as a sphere which will include the planets as far as Neptune, the weight of the extremely rarefied matter added to the solar system would be in kilograms, $\frac{4}{3}\pi(6400000\times24000\times30)^3\times0{\cdot}00065$ kilog.; the weight of the sun is $\frac{4}{3}\pi(64000000)^3\times5{\cdot}6\times324000$ kilog. The first is 100,000 times as great as the second. And this amount of matter would be added to the solar system.—*Comptes Rendus*, Oct. 9, 1882, p. 612.

M. G. A. HIRN presents two objections to Siemens' new theory of the sun. The first is based upon dissociation effects produced by the great heat of the sun. It is perhaps true as Siemens asserts that the compounds which are dissociated under his hypothesis by the effect of the sun in space, in returning toward a center of force like the sun can recombine and restore the lost energy to the sun, but these elements reformed at a certain distance, in falling to the center of the sun, would be dissociated again and would use up the heat they gave off in becoming compounds again, and therefore no gain would be made by the cycle of operations. The second objection urged is the following: If the solar radiation or the radiation of a star is employed in this work of chemical dissociation of the hypothetical matter disseminated through space, the intensity of the light of the star should suffer, and their light should diminish much more rapidly than the law of inverse squares of the distances. Hirn also gives a numerical calculation to support M. Faye's objections to Siemens' hypothesis.—*Comptes Rendus*, Nov. 6, 1882, pp. 812–814. J. T.

6. *Comparative observations upon telluric and atmospheric lines of the spectrum, for the study of absorption of the atmosphere.*—The atmospheric lines in the solar spectrum afford a means, according to CORNU, of obtaining the absorption of the atmosphere. If ε is the total quantity of the absorbing substance, and if, at two different periods, one observes in the solar spectrum the equality of intensity of the telluric line produced by this absorption with the same metallic line at two different altitudes h of the sun, the relation $\frac{\varepsilon}{\sin h}=\frac{\varepsilon'}{\sin h'}$, results. Certain groups of telluric lines can be selected; these are specified in Cornu's paper. —*Comptes Rendus*, Nov. 6, 1882, pp. 801–806.

JANSSEN had previously called attention to a method analogous to that proposed by Cornu, in which the study of the spectrum of aqueous vapor was conducted by means of a tube which was filled with this vapor, and a comparison was made with

the telluric lines in the spectrum. He commends the ingenuity of Cornu's method and reviews the history of the discovery of telluric lines.—*Comptes Rendus*, Nov. 13, 1882, pp. 885–890. J. T.

7. *The Electrical Congress.*—The International Electrical Congress which has lately been in session in Paris is "the outgrowth of the Congress of Electricians which was held a year ago in Paris. That body requested the French government to invite other nations to unite in constituting three international commissions for the study of the following problems:

I. A redetermination of the ohm.

II. (*a.*) Atmospheric electricity. (*b.*) Protection against damage from telegraphic and telephonic wires. (*c.*) Terrestrial currents on telegraphic lines. (*d.*) Establishment of an international telemeteorographic line.

III. Determination of a standard of light."

The Congress assembled, according to this request, in Paris, October 16, 1882, and adjourned on October 26, 1882, to the first Monday of October, 1883. It was concluded by the Congress that there is too great discrepancy between the various values of the ohm which have been obtained by different observers to enable a decision to be reached in regard to its value. All the governments participating in the Congress are appealed to by France to encourage independent redeterminations of the value of the ohm, and of the Siemens' mercury unit. The Section on Earth Currents and Lightning Conductors recommended that the governments should favor systematic observations of atmospheric electricity upon their telegraphic systems; that independent lines should be instituted for the study of earth currents; that the long subterranean telegraphic lines running north and south should be used also for this purpose; that simultaneous observations should be made over the surface of the globe. The Section on a standard of light were in favor of employing as a standard the light emitted by a square centimeter of melting platinum. J. T.

II. Botany and Zoology.

1. *The Lignified Snake from Brazil.*—The Popular Science Monthly for November, and the Bulletin of the Torrey Botanical Club, for the same month, have reproduced an account given in the French *La Nature* last April, of a remarkable phenomenon. The abstract in the Bulletin of the Torrey Botanical Club is the most condensed, and the essential part is copied here: the cut illustrating the object, however, is poor; that in the Popular Science Monthly is a somewhat better representation.

"The object represented is a small Brazilian reptile—the jaracaca—which was found within the trunk of an ipé-mirim, a tree of common occurrence in the province of Matto Grosso, to the north of the Amazons, where the specimen was discovered. The piece of wood containing the reptile, after an examination by the scientists of Rio de Janeiro, was taken to France by Mr. Lopez

Netto (Brazilian Minister to the United States) and placed in the hands of Mr. Louis Olivier, who, after a careful study of the specimen, submitted the results thereof to the Botanical Society of France.

"What is astonishing," says Mr. Olivier, in an article on the subject in La Nature, "is that the entire body of the snake is lignified,* the anatomical study that I have made of it having shown me that it consists of cells and fibres like those of the secondary wood which surrounds it. It is impossible to explain the fact by saying that there has occurred a formation of these elements in a hollow, which, having been traversed by the animal, has preserved the form of the latter; for on the piece of wood it is not only the contour of the snake that is visible, but, indeed, the whole relief of its body.

Just beyond the head there is likewise observed in relief a small cylinder which appears to represent the larva of an insect. It seems, then, that the snake, in pursuing the latter into a fissure in the tree, has insinuated itself between the wood and the bark into the cambium-layer, which is well known to be the generator of wood and secondary liber. The function of this cambium-tissue is two-fold; in the interior it gives rise, in a centripetal direction, to ligneous elements, the youngest of which are consequently found at periphery of the wood; but, toward the exterior, on the contrary, it produces, in a centrifugal direction, liber-fibres, elongated cells, and prosenchymatous elements, the youngest of which are therefore, situated on the internal surface of the bark. If, then, a foreign body be introduced as far as the external limit of the wood, it will, in a few years, become invested with a series of ligneous layers, which are themselves protected by an abundance of bark. Now, in the case under consideration, not only has there been an investment of concentric zones around the reptile, but, besides this, cells and ligneous fibres derived from the cambium-tissues have been substituted for the elements which constituted the external portions of the snake in measure as these have become absorbed. The places that these occupied have, as they gradually disappeared, been taken by secondary wood, whose hypertrophy is proved by the very relief of the snake's body." So far M. Olivier.

"The result, as in cases of petrifaction, is that in some parts of the body certain delicate details of the animal's organization are clearly visible. This is especially the case with regard to the nostrils and orbits, and to the arrangement of the scales and cephalic plates over the entire half of the surface of the head."

The narrative in the Popular Science Monthly adds from another source the names of the distinguished botanists who were present at the session of the Botanical Society of France, and who are said to have adopted the view of M. Olivier. The *Bulletin* of that Society in which the proceedings of that meeting is recorded have not yet come to our hands. We shall be much surprised if it fully bears out this statement.

* Except the center, in which are found the constituent elements of the animal.

Through the kindness of the Brazilian Minister, we have seen and examined the original specimen, and have been presented with an electrotype of it. It is a great curiosity. The resemblance to a snake is wonderfully close, although "the scales and cephalic plates," which Mr. Olivier identifies with those of a particular Brazilian snake, exist only in a lively imagination. The snake-like surface is covered by delicate meshes of woody fibers; and here and there particular fibers or woody threads can be traced from the body to the woody surface.

The adopted explanation requires us to suppose that a snake had forced his way between the bark and wood of a living tree, in a position exactly under a grub or larva; had perished there when within half an inch of its prey; was somehow preserved from decay, even to the eye-sockets and the markings of the skin, until a woody growth had formed, the elements of which replaced the whole superficial structure of the animal,—until the animal was lignified! Two other and more probable explanations have suggested themselves. One is, that the snake-like body is of the nature of a root, an aerial root, like those of a *Clusia* or a *Ficus*, which was making its way between bark and wood; and that the supposed larva is an incipient root of the same kind. The other supposes that the sinuous course is the track of a wood-eating larva or some kind of insect, the burrowing of which had not destroyed the overlying liber: consequently the new growth filling the space (except at certain points) had naturally assumed the likeness of a snake. This explanation was suggested by Professor Wadsworth of Cambridge, examining the specimen along with the writer; and it is to be preferred. Still, that head and neck should be so well outlined, and the former so well represent a pair of orbits, were surely most wonderful. But a close inspection of the electrotype showed that there had been some cutting away at the right side of the neck, and that the narrowing there was in part factitious; and less decisive indications suggested that other outlines had been touched up. The subsequent inspection of the original confirmed this; and likewise enlightened us about the eyes. For the left orbit was found to occur, not in a woody structure, like that of the right side, but in a dark material having the appearance of pitch or cement of some sort.

We may rest assured that whatever there may be which is factitious in this most curious *lusus naturæ*, originated before it came into the hands of His Excellency the Brazilian Minister at Washington. If these marks were not discerned by any of the Parisian *savants* in question—which we are slow to believe—they are less likely to have been noticed by Señor Lopez Netto, whose honor and good faith are incontestable. A. G.

2. *Flora Peoriana, Die Vegetation im Clima von Mittel Illinois.* Von FRIEDRICH BRENDEL.—An imperial octavo, of 107 pages, interesting for contents and very curious in form and origin, being in German, and printed at Buda-Pesth, at the printing-office of the Franklin Society of that town, and as being a part of the

fifth volume of the *Természetrajzi Füzetek*, edited by the National Hungarian Museum. In this treatise, Dr. Brendel discourses from his full knowledge of the topography, climate and vegetation of Illinois, and in particular of the relations of the latter to the former; and he ends with a Catalogue of the Flora around Peoria, his residence; adding to each species an abbreviated indication of its geographical range, also specifying species which on either hand approach the limits of his district. So that this is altogether an important contribution to the phytology of the United States. A. G.

3. *A Monograph of the Genus Lilium;* by HENRY JOHN ELWES, F.L.S., F.Z.S. Illustrated by W. H. Fitch, F.L.S. 1880. Elephant folio, London, March, 1877—May, 1880.—This sumptuous volume contains the most complete and best arranged account of the genus *Lilium* that has yet appeared. Every species known to the author, and by any means accessible to him, is here figured in natural size and colors, the drawing and coloring being in most instances from living specimens. Forty-six species are thus represented, together with several marked varieties and hybrids, in forty-eight full-page plates; with accompanying text giving scientific descriptions in Latin and English, the synonymy, the history of each species, its relations, etc. In an introduction are given a condensed history of the genus, a discussion of the general relations and arrangement of the species, their geographical distribution (illustrated by maps, and by an excellent photograph of a scene in the Northwest Himalayas where *Lilium polyphyllum* is found); and directions for their culture are also given. The author modestly and unduly distrusts his own judgment as a scientific botanist, and follows Mr. Baker's monograph as far as he finds it possible. He repeats Mr. Baker's Latin descriptions, with only occasional and generally very slight alterations, but wisely differs from him, not only in his limitation of species, but in their grouping. He recognizes but two main divisions, *Cardiocrinum* and *Eulirion*—the first including only the two very peculiar Asiatic species, *L. giganteum* and *L. cordifolium*. The other proposed sections, *Martagon*, *Isolirion*, etc., he considers too artificial to be kept up.

As American species he retains and illustrates the eastern *L. Philadelphicum*, *L. Catesbœi*, *L. Canadense*, *L. superbum* and *L. Carolinianum.* Of the more recently proposed *L. Grayi*, of the Southern Alleghanies, he had seen no specimen before the completion of his work. Of Pacific Coast species figures are given of *L. Washingtonianum* and var. *purpureum*, *L. Parryi*, *L. Humboldtii*, *L. pardalinum* with var. *angustifolium*, *L. parvum*, *L. maritimum* and *L. Columbianum.* The var. *purpureum* of the first species is obviously more than a variety; and it is only through mistake that *L. rubescens*, of the Botany of California, a quite different species of the Coast Ranges, has been supposed to have any connection with it. The forms of *L. pardalinum* are left somewhat in confusion, inasmuch as the plate which repre-

sents the type is lettered "*L. Californicum*" and entitled in the list of contents "Var. *Californicum*," while the var. *angustifolium* is figured as "*L. pardalinum.*"

Of the Japan species that are recognized, *L. medeoloides* was founded upon what is pretty certainly only an undeveloped specimen of *L. avenaceum.* Oldham's Corean specimens, which are referred to *L. medeoloides*, and from which the figure is drawn, represent possibly a distinct species. The figure of *L. avenaceum* itself is perhaps the least satisfactory of any in the volume.

Great should be the praise of an amateur botanist who, inspired purely by love of the beautiful objects he cultivates, seeks to know them thoroughly, and notwithstanding other engrossing occupations, devotes his time and means to such an investigation as this, and enriches the science with such a noble monograph. The satisfaction which the author may take in the service he has rendered to botanists may be added to the gratification referred to in the dedication: "To my Wife, who first led me to the culture of plants, and whose love for Lilies suggested to me their study, I dedicate this book, in memory of the happy days I have spent in its preparation." S. W.

4. *F. A. Ford on the Pelagic fauna of Freshwater Lakes.*—A translation of Professor Ford's paper on this subject, from the Biologisches Centralblatt, ii, 299, is given in the Annals and Magazine of Natural History for October. Its principal points are the following: The pelagic, or deep-water fauna of the lakes of Europe is throughout very similar in species, and consists, fishes excluded, almost wholly of small Entomostracans of the Daphnia and Cyclops groups, with one Cypris. They have seasonal periodicity, some kinds disappearing in summer, or in winter, or spring or autumn, when they exist only in the state of resting-eggs. They come to the surface at night and descend again with the returning light, and thus making a daily migration. Weismann hence regards them as nocturnal animals which keep at the extreme limit of light; but it is better to say near this limit. The wide distribution of the fauna may have taken place by passive migration in the state of resting-eggs through the aid of migratory birds (ducks, grebes, gulls, etc.). The cause of the differentiation of the pelagic fauna is attributed to two phenomena—the daily migration above mentioned, and the action of the land-breeze and lake-breeze. At night, when the species are at the surface of the lake the land-breeze drives them to the middle of the lake; as day returns they sink and so escape the action of the lake-breeze which would drive them to the shore again. The action tends to make them pelagic and confine them to that region; and thus "a differentiation takes place by natural selection, until at last, after a certain number of generations, there remain only the wonderfully transparent and almost exclusively swimming animals, which we know." Two of the species, *Leptodora hyalina* and *Bythotrephes longimanus* appear, however, as held by Pavesi, to be of salt-water origin.

5. *A new genus of spherical Rhizopods.*—Mr. H. B. BRADY describes, in the Magazine of Natural History for September, a white porcellanous spherical foraminifer, obtained by the *Challenger* expedition at a depth of 1,950 fathoms, in lat. 53° 55′ S., long. 108° 35′ E., or roughly about 25 degrees south of the southwestern corner of Australia. It is a tenth of an inch in diameter, and is made up of concentric layers each consisting of a large number of chamberlets arranged more or less regularly in single series. The chamberlets of the same layer communicate by short lateral stolons, those of successive layers by the pores which formed the superficial apertures of the previous layer. The surface is areolated, owing to the arrangement and the small convexity of the chamberlets. The material brought up in the dredge was a white diatom-ooze, composed chiefly of diatoms, radiolarians, sponge spicules, and other siliceous organisms, with seventeen species of rhizopods of arctic habit.

III. ASTRONOMY.

1. *Transit of Venus.*—The daily papers have given quite fully the degree of success and failure had in observations of the Transit of Venus, especially in the United States, with more or less of detail of the observations themselves. There was upon the whole a much greater degree of success than could have been reasonably expected. At most of the observatories in the United States there were secured one or more of the four contacts. Particulars of these and of the physical appearances of Venus must, to have permanent value, be given by the observers themselves, in their own language.

The heliometer was thought by Lalande in the last century, even in its then imperfect form, to be the best instrument for observing the Transit. In its present perfected form it is thought by many astronomers, especially in Germany, to be the most powerful means we even now have of observing the Transit for the purpose of measuring the solar parallax. At New Haven the six-inch Repsold heliometer was used by Dr. Waldo and Professor Kershner continuously throughout the whole time of the Transit. The clouds interfered but little with this work, about 250 pointings of the instrument with corresponding readings being secured. These constituted twenty-seven more or less complete single sets of measurements across the sun, each set when complete being composed of eight pointings. There were in addition 20 direct measures of the diameter of Venus, 33 of the sun's diameter before and after the Transit, and 14 position angles near the first and fourth contacts.

Each of the four German parties had three-inch heliometers. At Hartford the clouds entirely prevented observations for the first hour, yet after that time five double sets of observations were secured by Drs. Müller and Deichmüller, together with various other valuable measurements.

At Aiken, the second northern German station, the clouds interfered somewhat more than at Hartford, but Dr. Franz is said to have secured three double sets of measurements.

At Martinique, the French party under M. Tisserand had a four-inch heliometer loaned by the Russian Government. Most unfortunately the clouds covered the sun immediately after the first contact, and apparently prevented further observation.

There are three southern stations armed with this instrument, no one of which has as yet been heard from. These are the two German parties under Professor Auwers at Punta Arenas in the Straits of Magellan, and Dr. Hartwig at Bahia Blanca, and the French party under M. Perrotin, which has a second Russian heliometer. Returns from these three parties are looked for with no little interest.

The American Government parties have been equipped with photo-heliographs under the belief that this instrument furnishes the best material for computing the solar parallax. The parties have all been reported to have been successful, except one not yet heard from, viz: that under Lieut. Very at Santa Cruz.

The French parties had photographic apparatus, though this was not regarded as an essential part of their equipment.

At a large number of observatories in the United States photographs have also been taken. At New Haven, Mr. Willson secured about 150; at Princeton, Prof. Young 188; at the Lick Observatory, 147 were taken. Whatever results can be had from photographs which we are now able to make have undoubtedly been secured.

The English and French parties relied upon contact observations. There were ten English parties, at Kingston (Copeland), Barbadoes (Talmage), Bermuda (Plummer), Madagascar (Perry), Cape Town (Gill), Aberdeen Road (Finlay), Montague Road (Marth), Brisbane (Morris), New Zealand (Tupman), S. American coast (Wharton). At Brisbane there was a total failure; Mr. Perry and Capt. Wharton have not been heard from. The other seven parties were successful.

There were nine French parties, Port au Prince (D'Abbaie), Puebla (Bouquet de la Grye), Martinique (Tisserand), St. Augustine (Perrier), Santa Cruz (Fleuriez), Chili (Bernardières), Chubut (Hatt), Rio Negro (Perrotin), and Oran (Janssen). Of these, Puebla, St. Augustine and Oran were successful, and Martinique failed.

There were four Brazilian stations, from none of which have we heard: St. Thomas (De Jeffe), Magellan (Cruls), Pernambuco (Lacaille), and Rio de Janeiro (De Souza Jacques). No Austrian, Russian or Italian parties were sent out.

In Europe the ingress was visible where it was clear weather, but unfortunately it was cloudy over England and France. In Ireland, at Potsdam and at Rome successful observations were made.

2. *Observations of the Transit of Venus at the Allegheny Observatory;* by S. P. Langley (in a letter to the editors, dated

Allegheny, Dec. 6, 1882).—The Transit of Venus was accompanied here by clouds, which came on between 1st external and 1st internal contact. Owing to these it was only certain that the latter occurred between $21^h\ 04^m\ 45^s\cdot9$ and $21^h\ 05^m\ 16^s\cdot0$ Allegheny mean time. The sky remained clouded till the close. A very curious and unexpected phenomenon was witnessed, however, during from six to eight minutes (counted from the time the planet was half on the disc). Upon the part of the planet *without* the sun, when the very faint bounding line of light, often observed before, was first becoming visible, as the planet was about half on, there was seen a distinct bright spot, extending through about 30° of the circumference and extending inward from the planetary limb to perhaps one-quarter of the radius. It is very noticeable that this brightness was not in a line joining the centers of the sun and planet, but was distinctly on one side. It was seen by me with the large Equatorial and a power of 244 on the polarizing eye-piece, and so plainly that I could even notice the gradation of the light, which was brightest at the circumference. Though my own observation was too clear to admit of doubt, there is independent confirmation in an observation by Mr. J. E. Keeler, who was observing near me with a much smaller telescope. We saw it independently, and independently estimated its position angle on the planetary disc within 10° of each other. What it was I cannot say. It is certain that it was seen.

3. *Elements of the great Comet of* 1882; by E. Frisby, Professor of Mathematics, U. S. N. (Communicated by Vice-Admiral Rowan, Sup't U. S. Naval Observatory.)—The following elements were computed from three observations made at the U. S. Naval Observatory; the first and last being made with the Transit circle, and the middle one compared with a known star which was afterwards observed on the Transit circle.

Wash. M. T.	App. α.	App. δ.
Sep. 19·9697877	$11^h\ 14^m\ 18^s\cdot94$	$-\ 0°\ 34'\ 29''\cdot7$
Oct. 8·7204363	10 28 6·63	−10 40 22·6
Nov. 24·7009228	9 6 16·22	−27 21 26·7

From these observations we deduce

Perihelion Time = Sep. 17·2228200 Greenwich mean time.

$$\left.\begin{aligned} \Omega &= 346°\ \ 1'\ \ 7''\cdot91 \\ \pi - \Omega &= \ \ 69\ \ 36\ \ 12\cdot79 \\ i &= 141\ \ 59\ \ 52\cdot16 \\ \phi &= \ \ 89\ \ \ \ 7\ \ 42\cdot70 \\ \log a &= 1\cdot9331366 \\ \log q &= 7\cdot8904739 \end{aligned}\right\}\ 1882\cdot0$$

$$\text{period} = 793\cdot689 \text{ years}$$

$$\delta\lambda \cos\beta = -\ 0''\cdot06 \qquad \delta\beta = +\ 0''\cdot01$$

$$\begin{aligned} x &= r\,[9\cdot9951411]\sin(170°\ 42'\ 12''\cdot72 + v) \\ y &= r\,[9\cdot9877234]\sin(262\ \ 46\ \ 57\cdot39 + v) \\ z &= r\,[9\cdot4435130]\sin(\ 49\ \ 20\ \ 25\cdot11 + v) \end{aligned}$$

The observations as given were afterwards corrected for parallax by means of elements previously computed. These elements

bear a considerable resemblance to Comet I, B. C. 371; and it may possibly be its third return, a very brilliant comet having been seen in full daylight A. D. 363.

Washington, Dec. 19, 1882.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Science—A new American weekly scientific Journal.*—It is announced that a new scientific journal will be shortly commenced at Cambridge, Mass., under the editorship of Mr. S. H. Scudder. It will be published weekly in large octavo in numbers of at least twenty-four pages. It is intended to occupy on this side of the Atlantic very much the same position long well filled by *Nature* in England. The scope of Science is broad. It is proposed to include condensed results of original researches, reviews of scientific works, weekly reports of scientific progress, of the contents of current periodical literature, and of the proceedings of scientific societies throughout the world; also papers on the practical applications of mechanics and physics, discussions of the methods of teaching the natural and physical sciences, and of other topics of general interest. The name of the editor-in-chief, and the long list of names that has been published of those who have promised to support this new journal is a guarantee that its standard of excellence will be high and that it will be well maintained. Such a journal cannot but exert a powerful influence for good in the development of American science. Among the names of those who have contributed largely to the pecuniary support of the undertaking, that of Mr. Alexander Graham Bell stands foremost, who is indeed mentioned as the founder of the enterprise. The publisher is Mr. Moses King, of Cambridge; subscription price, five dollars, post-paid.

2. *Report from the E. M. Museum of Geology and Archæology at Princeton*, for the year 1881–2, by Professor A. GUYOT, Director.—The Princeton Geological and Paleontological collection has become one of great value and interest since its recent acquisition of 5,000 specimens of fossils; and, being well arranged, labeled and catalogued, it is one of the best in the country for instruction in these departments. The report just issued mentions the addition also of 2,600 specimens of minerals, from Mr. A. MacMartin, a graduate of the college, of a large collection of Archæological implements, representing the stone, bronze and iron ages of Switzerland, and the paleolithic and neolithic ages in France, and of ethnological collections from western America. The Report announces that a new number of the Bulletin will soon appear which will contain a description of the skulls of two large mammals, as yet unknown to science. A brief account of one, in advance of the fuller publication, is given by the authors on page 223 of the last volume.

3. *Proceedings of the Davenport Academy of Natural Sciences.* Vol. iii, Part 2. Pages 65–192, with 5 plates. 8vo. Daven-

port, Iowa, 1882.—This number of the Proceedings is devoted almost wholly to American Archæology, several important papers on this subject being published in it, and the plates being devoted to illustrations of them. Their authors are, G. Seyffarth, W. H. Pratt, C. T. Lindley, Dr. W. J. Hoffman, Rev. A. Blumer and Rev. J. Gass. Other shorter papers treat of the habits of Western Cicadæ, by J. D. Putnam; two new species of *Oxytheca*, from Southern California, by Dr. C. C. Parry; Geological notes by Mr. W. H. Pratt, and notices of Explorations in Idaho and Montana, by E. L. Berthoud.

Madeira Meteorologic, being a paper on the subject read before the Royal Society, Edinburgh, May 1, 1882, by C. Piazzi Smith, Astronomer Royal for Scotland. 84 pp. 12mo. Edinburgh. 1882. (David Douglas.)

The Climatic changes of later geological times. Part III. By J. D. Whitney. Memoirs of the Museum of Comparative Zoology, Cambridge, 1882.

Selections from Embryological Monographs, compiled by A. Agassiz, W. Faxon and E. L. Mark. 1. Crustacea, with 14 plates, 4to. Memoirs of the Museum of Comparative Zoology, Cambridge, vol. ix, No. 1. 1882.

Celestial charts made at the Litchfield Observatory of Hamilton College, Clinton, N. Y., by C. H. F. Peters. Charts 1 to 20. 1882.

Mineral statistics of Michigan for 1881. 262 pages 8vo, with numerous sections. Lansing, Michigan, 1882.

The Geological and Natural History Survey of Minnesota. 10th Annual Report, for the year 1881. N. H. Winchell, State Geologist. 254 pp. 8vo, with maps and plates. St. Paul, Minn., 1882.

First Annual Catalogue of the State Museum of California, Henry G. Hanks, State Mineralogist. 350 pp. 8vo. Sacramento, 1882.

Transactions of the Wisconsin Academy of Sciences, Arts and Letters, vol. v, 1877–81. 364 pp. 8vo. Madison, Wisconsin, 1882.

Transactions of the Linnæan Society of New York, vol. i, 168 pp. 8vo, with plates. New York, 1882.

Geological Survey of Newfoundland—Report of progress for the year 1881. Alexander Murray, C. M. G., Director. 16 pp. 8vo, with maps. St. John's, Newfoundland.

The Theory of the Gas Engine, by Dugald Clerk. 164 pp. 16mo. New York, 1882. (D. Van Nostrand).

Nachträge zur Dyas II, von Dr. Hanns Bruno Geinitz und Dr. J. V. Deichmüller. 46 pp. 4to, with 9 plates. Kassel and Berlin, 1882.

OBITUARY.

FRANZ VON KOBELL, the veteran mineralogist of Munich, died on the 11th of November last. The name of von Kobell has been identified with Mineralogy for more than fifty years, and the many excellent original papers, chemical, optical and crystallographic, which he has published, bear testimony to the industry that characterized his long life. In addition to minor researches he was the author of an elementary work on general mineralogy which has gone through five editions, of a history of mineralogy, and of a series of tables for determining mineral species which have been widely used and valued, and of which eleven editions have been published. Among the results of his optical work the *stauroscope* was the most important. Professor von Kobell was a man of unusual general culture, being a poet as well as mineralogist, and in his character he was most attractive; the many American students to whom he has shown kindness will never forget the impression which his genial courtesy made upon them.

THE

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[THIRD SERIES.]

ART. VII.—HENRY DRAPER.

HENRY DRAPER died at his residence in New York City, on the 20th of November last. He had entertained the National Academy of Sciences at dinner on the evening of the 15th and went from the table to his bed with a severe attack of pleuritis. Hope alternated with fear until Sunday, when pericarditis developed and, in spite of the best medical skill, he died about four o'clock on Monday morning.

Professor Draper's career has been an exceptionally brilliant one. He was born in Virginia in 1837, his distinguished father, John William Draper, being at the time Professor of Chemistry and Physiology in Hampden Sidney College. Though he attended in early life the primary and preparatory schools of the University of the City of New York (to which place his parents removed when he was only two years of age) and subsequently became an undergraduate student at the same University, his real education was received in his own home. The eminence of his father as a teacher, an author, a philosopher and an investigator, created an atmosphere of scientific culture about him of the highest tone. It could not but happen, that Henry, breathing constantly such an atmosphere, should be permeated with its spirit and early devote himself to research as the highest attainable purpose in life.

At the age of twenty, and before taking his medical degree, he made his first research, which was afterward published as his graduating thesis. It was on the function of the spleen and

was illustrated with microphotographs of great excellence. This early study of photography led him to the discovery of the value of palladious chloride as an intensifier. From this time dates his interest in the photographic studies in which he afterward attained such eminence. Shortly after graduation he spent a year in Europe, and made a visit to Lord Rosse at Parsonstown, Ireland. Here he saw the great reflector so well known to science, and became very much interested in it, because of its photographic possibilities. Upon his return he set about constructing a metal speculum fifteen inches in diameter, which he completed in 1860. In 1861, owing to a suggestion made by Sir John Herschel to his father, he abandoned speculum metal and made several mirrors of silvered glass 15½ inches in diameter. The details of the construction and mounting of these mirrors were published as a monograph, in 1864, by the Smithsonian Institution. With this instrument a great amount of astronomical photography was done, the piece of work best known being his photograph of the moon. In perfection of detail it was far in advance of any previous attempt. The original negatives, of which over 1500 were taken, were about an inch and a quarter in diameter and they bore enlargement to three feet, and in one case to fifty inches, with excellent results. In 1870 he finished a second and larger reflector. Its mirror was also of silvered glass, twenty-eight inches in diameter; and like the former one, was ground, polished, corrected, silvered and mounted solely by himself. The first telescope had been mounted in the Newtonian form. The new one was equatorially mounted and at first of the Cassegrainian form; but subsequently he improved it by making the secondary mirror plane. In 1875 an achromatic refractor of twelve inches aperture, made by Alvan Clark & Sons, was placed upon the same axis. And in 1880 this was exchanged for a telescope of a little less aperture, but furnished with an extra lens as a photographic corrector. A five-inch finder completed this unrivalled photo-telescopic battery. All these instruments were mounted in an observatory built on his father's grounds at Hastings-on-Hudson. At first, it consisted of but a single dome, containing the 15½-inch reflector; but subsequently, a second and larger dome was added, and also the rooms needed for the transit instrument and chronograph, the photographic laboratory and the workshop. Though a wooden building of but one story, unpretending in appearance, its internal arrangements were admirable, and its facilities for astronomical photography entirely unsurpassed.

The work at the observatory was done chiefly during the summer months; Dr. Draper residing then at his country place at Dobbs Ferry, two miles distant. In the winter, he carried

on investigations at his house in New York, those being selected for the purpose which did not require a telescope. At first, two rooms in the third story were devoted to these researches. But in 1880 he built a special physical laboratory as the third story of his stable in the rear of his house, this laboratory being connected with the house by a covered way. The equipment of this laboratory was superb. A siderostat by Alvan Clark & Sons, placed upon the roof, furnished abundant sunlight, directed to any part of the room by a secondary mirror. An Otto gas-engine of four-horse power gave motion to three dynamo-machines for the production of electric currents. One of these was a Gramme machine, wound double, and which by an ingenious modification of his own, could be made to give a continuous or alternating current at will. The second was an Edison machine, used mainly to light the laboratory by means of incandescent lamps. The third was a Maxim machine used for producing arc lights and also to feed the field of the Gramme machine. For the production of the electric spark, an induction coil of the largest size was employed, made by Ruhmkorff. Used with the direct current it gave 15-inch sparks readily, though the safety points were usually set at 10 or 12 inches to avoid perforation. With the Gramme direct current this coil yielded 1000 ten-inch sparks per minute. With the alternating current, the spark, though silent and only one-quarter as long, was of much greater volume; so that when heavily condensed, the discharge was like the rattle of musketry. The optical and photographic appliances were of the finest. Complete spectroscopes and cameras were there, as well as the lenses, prisms and gratings, of various materials and of the best workmanship, needed to extemporize those in research. A lathe, file bench and carpenter's bench, each with its full set of tools, completed the appointments of this beautifully finished room.

With these facilities at his command, the original work which Dr. Draper did was of an exceedingly high order. Upon the completion of his large reflector, he applied it at once to the photographic reproduction of stellar spectra; and in 1872 he obtained a photograph of the spectrum of α Lyræ (Vega) showing dark lines; a result then unique in science. Continuing his labors he obtained more than a hundred stellar spectra of great excellence; latterly, and especially when he used the photographically-corrected refractor, taking upon the same plate the spectrum of Venus, Jupiter or the moon, for reference. In 1873, he published the finest photograph of the diffraction spectrum ever made. It included upon a single plate the region from wave-length 4350, below G, to wave-length 3440, near O. A steel plate from this photograph was introduced by

Secchi into his great work on the sun, and in 1880 a lithograph of it was published in the Proceedings of the British Association as the most suitable reproduction extant, for determining the wave-length of the fixed lines. The spectrum was obtained with a Rutherfurd grating of 6481 lines to the inch, and in the photo-lithograph a portion of Ångström's drawing is reproduced for comparison with it. In 1876 he succeeded in face of great difficulties, in photographing the solar spectrum and the spectrum of an incandescent gas upon the same plate with their edges in contact; thus admitting of accurate comparison between the lines. He then noticed that, while the lines of the iron and aluminum used as electrodes coincided exactly with their proper dark solar lines, the lines of oxygen corresponded to bright solar lines. He was led to conclude therefore, not only that oxygen actually existed in the sun, but that it existed there under conditions, probably of temperature, which caused it to radiate more light than the surrounding solar masses. At the same time therefore, that he announced his discovery of oxygen in the sun, he proposed an important modification in the theory of the solar constitution. These conclusions were so radical that he deemed no labor too great which should strengthen them. He continued his researches in this direction and early in 1879 produced a photograph of marvellous excellence on a much larger scale which showed the coincidences, especially of groups, so accurately as to leave no longer any doubt upon the subject. He was anxious, however, to obtain conditions which should make the lines of oxygen sharper; and had made special preparation for the accomplishment of this result during the present winter.

While using the gelatino-bromide dry process in stellar spectrum photography, Dr. Draper conceived that the great sensitiveness of these plates might enable him to secure a photograph of a nebula and so to obtain an accurate record of its present condition with a view to future comparisons. On September 30, 1880, he obtained, after an exposure of 57 minutes, a photograph of the great nebula of Orion, which was sufficiently perfect to enlarge. In order to get this much fainter nebula, the plate had of course, to be over-exposed for the stars. On the 11th of March, 1881, a second enlarged photograph was published, much more full in its details, the exposure being 104 minutes. And finally on the 14th of March, 1882, he succeeded after an exposure of 137 minutes, in securing a photograph wonderful in its detail, showing stars of the 14·7 magnitude on Pogson's scale, invisible to the eye, and giving the faint outlying regions of the nebula with absolute perfection. This result must be regarded as the greatest triumph which astronomical photography has yet achieved. Besides these more

difficult photographs, Dr. Draper obtained some excellent ones of the spectrum of the nebula. These are chiefly interesting because, besides the general bright line spectra characteristic of this nebula, they show in several places traces of continuous spectra suggesting condensation.

Professor Draper's preëminence in celestial photography led to his selection in 1874, by the Transit of Venus Commission of the United States, as the Director of the Photographic Department. During the spring of that year, he spent three months in Washington engaged in devising improved methods, in testing instruments and materials, and in instructing those who were to use these methods how to obtain the best results with them. Although he did not accompany any of the expeditions, yet so conspicuous were his services that, upon recommendation of the Commission, Congress ordered a special gold medal to be struck in his honor at the Philadelphia Mint. This medal is 46 millimeters in diameter and has upon the obverse the representation of a siderostat in relief, with the motto: "Famam extendere factis hoc virtutis opus." On the reverse is inscribed the words: "Veneris in sole spectandæ curatores R. P. F. S. Henrico Draper, M.D., Dec. VIII, MDCCCLXXIV;" with the motto: "Decori decus addit avito."

In 1878, Professor Draper organized a party of five persons to observe the solar eclipse of July 29th. The station which he selected for observation was Rawlins, in Wyoming, on the line of the Union Pacific Railroad. The expedition proved an entire success, Professor Draper himself securing an excellent photograph of the corona and also one of its diffraction spectrum, which appeared continuous. Others of the party detected heat in the corona and also faint dark lines in its spectrum. In 1880, Dr. Draper published an account of a photograph he had obtained of the spectrum of Jupiter, which appeared to him to afford evidence that this planet furnishes intrinsic light. The exposure required to get the spectrum was fifty minutes, that of the moon on the same plate being obtained in ten. In June, 1881, he photographed both the comet and its spectrum, using a slit and two prisms for this latter purpose. Three photographs were taken with exposures of 180, 196 and 228 minutes respectively, each having a comparison spectrum upon it.

Besides that spent in scientific work, Dr. Draper's time was largely occupied with his duties as instructor. In 1859 he was appointed on the medical staff of Bellevue Hospital, and served eighteen months. In 1860 he was elected Professor of Physiology in the Academic department of the University of the City of New York; a position which he held until the past year.

In 1866 he was elected to the chair of Physiology in the Medical Department of the University and made Dean of the faculty. He managed the affairs of the college with signal ability and, by a liberal use of his own private means, brought it successfully out of the trying position in which it was placed by the destruction by fire of its building in Fourteenth street. He severed his connection with the Medical School in 1873. For several years he had added Analytical Chemistry to the branches he taught in the Academic Department. Upon the death of his father in January, 1882, he was elected to succeed him as Professor of Chemistry, and gave the instruction in both chairs until the close of the collegiate year, when he resigned his connection with the University entirely.

Still a third portion of Professor Draper's time, and this no inconsiderable portion, has been given during the past ten years to the management of the large business interests in his hands. In 1867 he had married the daughter of Courtlandt Palmer, Esq., and upon his death in 1874, Dr. Draper was elected managing trustee of an immense estate, and was obliged to devote himself energetically to the work of reducing it to a solid investment basis. His success here has been as signal as in the work of scientific research and of instruction.

In 1861 Dr. Draper was appointed Surgeon of the Twelfth New York Regiment and served as such with distinction. In 1876 he was appointed a Judge in the Photographic Section of the Centennial Exhibition. In 1877 he was elected a member of the National Academy of Sciences and a member of the American Philosophical Society. In 1879 he received the election of Fellow of the American Association for the Advancement of Science. He was made a member of the American Academy of Arts and Sciences in 1881 and of the Astronomische Gesellschaft in 1875. In 1882 he received almost simultaneously the degree of LL.D. from his *alma mater* and from the University of Wisconsin.

Professor Draper's abilities were many-sided. In science, he was eminent in astronomy, in physics, in chemistry and in physiology. He was exceedingly able as a mechanician, as the telescopes in his observatory with their wonderfully accurate mountings, can testify. As a teacher he was clear, precise and considerate. As a business man he is said to have had no superior in the city of New York. In social life he was brilliant, entertaining, companionable. He made life-long friends often at the first contact, by the suavity of his manner and the charm of his presence. To get rest from the severe labors of the year and to fortify his constitution for the winter's strain, it had been his custom for eight years, to join his friends, Generals Marcy and Whipple of the U. S. army, for a month's hunt

in the Rocky Mountains during September. These expeditions he enjoyed greatly. He was an enthusiastic sportsman and a capital shot; and he entered upon the hunt with as much relish as he took a photograph. It was while out on such an expedition in 1877 that he made the important observations upon the suitableness of the air of that region for astronomical investigations. In 1882, the party was absent two months, traveling on horseback from the Union Pacific to the Northern Pacific Railroad; and when above timber line he was exposed to a severe and intensely cold snow storm.

Professor Draper had not published very extensively at the time of his death. This is the more remarkable as he was fond of writing, a trait no doubt inherited from his father. A list of his publications is appended to this notice. There can be little room to doubt that had he not been cut down so abruptly in the midst of a host of projected investigations, the world would have been enriched during the next twenty years with a wealth of discovery almost unparalleled.

Looked at from any stand-point, the death of such a man as Henry Draper cannot be viewed but as a calamity. At the age of 45 years, with very many years of good work apparently before him, with the experience and learning of the twenty years past added to a rich and varied natural endowment, giving promise of a scientific career of exceptional brilliance, it is no wonder that the world of science mourns his departure. Moreover he seemed to be just ready for his life-work. He had completed the building and equipment of his observatory and laboratory, and had arranged everything ready for experiment. He had given up his professorship and was reducing his business cares in order to get more time for research. He had stored his mind for years with precious facts which he hoped now to utilize in the highest investigations. Finally he had a most devoted wife who always acted as his assistant, and to whose skilled hand and thoroughly trained eye he has attributed much of the success he had already attained. Such men it is that the world is made poorer by losing. They are all too few, and when one drops from the ranks of honest and earnest workers, the gap is never completely filled. G. F. B.

List of Henry Draper's Original Papers.

1. On the Changes of Blood Cells in the Spleen. *New York Journal of Medicine*, III, v, 182–189, Sept., 1858.
2. On a new Method of Darkening Collodion Negatives. *Am. J. Phot.*, II, i, 374–376, May, 1859.
3. On a Reflecting Telescope for Celestial Photography. *Rep. Brit. Assoc.*, 1860, II, 63–64.

4. On the Photographic use of a Silvered Glass Telescope. *Phil. Mag.*, IV, xxviii, 249–255, 1864.

5. On a Silvered Glass Telescope and on Celestial Photography in America. *Quar. J. Sci.*, i, 381–387, Apr., 1864.

6. On the Construction of a Silvered Glass Telescope 15½ inches in aperture, and its use in Celestial Photography. *Smithsonian Contr.*, XIV, Part II, July, 1864.

7. Petroleum; its Importance, its History, boring, refining. *Quar. J. Sci.*, ii, 49–59, 1865. *Dingler's Polyt. J.*, clxxviii, 107–117.

8. American Contributions to Spectrum Analysis. *Quar. J. Sci.*, ii, 395–401, 1865.

9. A Text-book on Chemistry. New York, 1866.

10. Report on the Chemical and Physical facts collected from the Deep Sea Researches made during the voyage of the School-ship Mercury. *Rep. Comm. Pub. Charities*, New York, 1871.

11. On Diffraction Spectrum Photography. *Am. J. Sci.*, III, vi, 401–409, Dec., 1873. *Phil. Mag.*, IV, xlvi, 417–425. *Ann. Phys. Chem.*, cli, 337–350, 1874.

12. Astronomical Observations on the Atmosphere of the Rocky Mountains, made at elevations of from 4500 to 11000 feet in Utah and Wyoming Territories and Colorado. *Am. J. Sci.*, III, xiii, 89–95, Feb., 1877.

13. Photographs of the Spectra of Venus and α Lyræ. *Am. J. Sci.*, III, xiii, 95, Feb., 1877. *Phil. Mag.*, V, iii, 238.

14. Discovery of Oxygen in the Sun by Photography and a new Theory of the Solar Spectrum. *Proc. Am. Phil. Soc.*, July, 1877, 74–80. *Am. J. Sci.*, III, xiv, 89–96, 1877.

15. Observations on the Total Eclipse of the Sun of July 29, 1878. *Am. J. Sci.*, III, xvi, 227–230, 1878. *Phil. Mag.*, V, vi, 318–320.

16. On the Coincidence of the Bright Lines of the Oxygen Spectrum with the Bright Lines of the Solar Spectrum. *Am. J. Sci.*, III, xviii, 262–277, 1879. *Monthly Not. Astr. Soc.*, xxxix, No. 8.

17. On Photographing the Spectra of the Stars and Planets. *Am. J. Sci.*, III, xviii, 419–425, Dec., 1879.

18. On a Photograph of Jupiter's spectrum showing evidence of Intrinsic Light from that Planet. *Am. J. Sci.*, III, xx, 118–121, 1880. *Monthly Not. Astr. Soc.*, xl, 433–436.

19. On Photographs of the Nebula in Orion. *Am. J. Sci.*, III, xx, 433, 1880. *Phil. Mag.*, V, x, 388. *C. R.*, xci, 688; xcii, 173, 964.

20. On Photographs of the Spectrum of the Comet of June, 1881. *Am. J. Sci.*, III, xxii, 134, 1881.

21. On Photographs of the Spectrum of the Nebula in Orion. *Am. J. Sci.*, III, xxiii, 339–341, May, 1882.

ART. VIII.—*On a remarkable Fauna at the base of the Chemung Group in New York;* by HENRY S. WILLIAMS, PH.D., Cornell University.

MORE than a year ago the writer discovered, at the base of the Chemung Group at Ithaca, N. Y., two species of Brachiopods, which were hitherto regarded as peculiar to more western deposits, and a different geological horizon in America. These are a species of *Productus* described by Professor Hall as *P. dissimilis* (Iowa Geol. Rep., vol. i, Pt. II, p. 497), (entirely distinct from *P. dissimilis* of DeKoninck), and the form of *Rhynchonella* referred to Martin's species, *R. pugnus*, by Meek, in the Illinois Geological Report, iii, p. 450. Both species are decidedly Carboniferous in aspect. Their lowest range in the West is in beds referred to the Kinderhook group of Meek and Worthen, and to the Chemung, and to the Hamilton groups of the East.

During the summer of 1882 a fossiliferous stratum was examined a few miles south of Canandaigua Lake, at High-point, Naples, N. Y., containing *Productus dissimilis*, varietally identical with the Ithaca form, and a variety of *R. pugnus* type, but more like the species *R. acuminata* of Martin than the Ithaca or Iowa specimens. With these, a rich fauna was seen, the species of which are almost all different from the normal species of the New York Chemung fauna.

The author is indebted to the kindness of Professor J. M. Clarke, of Northampton, Mass., and Mr. D. D. Luther, of Naples, N. Y., for the discovery of these Naples beds. Recent examination of the material there collected reveals a fauna of more than ordinary interest.

The Ithaca rocks under consideration are, stratigraphically, about five hundred and fifty feet above the top of the Genesee slate, near the head of Cayuga lake.

In this section the Portage rocks are about three hundred feet thick. The Naples rocks are near the summit of an abrupt hill, called High-point, and lie about twelve hundred feet above the highest Genesee slate of that meridian, the dip being very slight.

The High-point fauna is in a calcareous stratum, of local extent, in the midst of brownish gray sandstones and shales. The stratum is made up of a mass of Crinoid stem fragments, shells, mainly Brachiopods, corals and Bryozoa, and what appear to be pebbles of a soft greenish shale.

The following species have been identified by the author:

Productus dissimilis Hall (not Koninck).
Rhynchonella pugnus Martin (a variety approaching young of *R. acuminata* Martin).
Orthis impressa, var. *Iowensis* Hall.
Fragments of Crinoid stems in abundance.
Strophodonta arcuata Hall.
Strophodonta arcuata, var. of the same (="*Str. quadrata* Calvin.")
Atrypa aspera, var. *occidentalis* H.
Fistulipora occidens H.
Fenestella, sp.
Spirifer Orestes Hall.
Spirifer Hungerfordi H. (a single imperfect shell, but corresponding with this species in all characters preserved).
Strophodonta canace H. and W.
Strophodonta ? reversa H.
Strophodonta, n. s. (presenting the characters of *S. reversa*, but not resupinate, as that species).
Chonetes, sp.
Rhynchonella ? contracta, H., '67, p. 417.
Fish Spines (? *Ctenocanthus*, near the *C. formosus* type), and a species of *Zaphrentis.*

Besides these, Professor Clarke has identified:

"*Streptorhynchus Chemungensis.*"
" *Spirifer disjunctus.*"
" *Extremity of mandible of Rhynchodus.*"
"*Ambocœlia umbonata*," and a few other forms which the author has not seen.

A comparison of this fauna with that of Lime Creek, near Rockford, Iowa, reveals a remarkable likeness, and especially among the species characteristic of the latter fauna. Although *strikingly Carboniferous in aspect*, several of its species are like those of Western "Hamilton" deposits, in which group it is retained by C. A. White, Report on Geol. Iowa, i, 1870. But the appearance of a large majority of the species in rocks, in New York State, known to be in the lowest part of the Chemung group, calls for a reconsideration of the whole question as to the equivalency of the beds concerned.

In 1858 (Iowa Geol. Rept., i, Pt. II), Professor Hall described a number of species from Lime Creek and the neighborhood of Rockford, Iowa, which he then referred to the Hamilton group. Afterwards, upon a more careful study of the rocks and species, Professors Hall and Whitfield described more species from the same beds, and referred the beds to the "Chemung group." (23d Report on Cabinet, New York State, 1873. This paper was prepared for the report of 1869, but was not published till 1873.)

In 1866, Professor Worthen (Illinois Geol. Report, i, p. 108), as had been proposed in 1861, by Meek and Worthen (this Journal, vol. xxxii, p. 167, defined the Kinderhook group as including all the western deposits lying between the Black slates and the Burlington limestone, including these beds of Iowa and their fauna. Leaving the question of the precise limits and horizon of the Lime Creek fauna of Iowa for more thorough investigation, we take this fauna alone for comparison with that of the New York rocks.

The species as described by Hall, 1858, and Hall and Whitfield, 1873, are as follows:

Orthis Iowensis,	*Crania familica,*
Strophodonta arcuata,	*Stromatopora incrustans,*
Strophodonta reversa,	*Fistulipora occidens,*
Strophodonta demissa,	*Zaphrentis solida,*
Productus dissimilis,	*Alveolites Rockfordensis,*
Spirifer Hungerfordi,	*Pachyphyllum Woodmani,*
Spirifer Whitneyi,	*Pachyphyllum solitarum,*
Atrypa reticularis,	*Campophyllum nanum,*
A. reticularis, var. *occidentalis,*	*Chonophyllum ellipticum,*
Strophodonta canace,	*Cystiphyllum mundulum,*
Cryptonella Calvani,	*Stomatopora alternata,*
Spirifer Orestes,	*Aulopora saxivadum.*
Spirifer cyrtiniformis,	

This is a list of twenty-five species, fourteen of which are Brachiopods. Of the fourteen, eight at least are represented in the fauna at High-point, Naples, N. Y., and constitute the large majority of all the Brachiopods found in that locality.

The *Rhynchonella pugnus* Martin, of beds at Rockford, Indiana, and at Chouteau, Missouri, and other localities of the Kinderhook group, has not been recorded from these Lime Creek beds of Iowa, but the author has lately examined specimens from beds of apparently the same horizon in the central portion of Iowa, which are identical with the Ithaca variety of *R. pugnus* Martin.

The Lime Creek fauna is certainly more closely related to the fauna of the Kinderhook group of Missouri, Indiana and Illinois than to any other fauna of the West, and contains some peculiar forms, and in the present state of information it seems appropriate to refer it to the Kinderhook group.

This *Rhynchonella pugnus* Martin, first identified by Meek, in Illinois, Geol. Rept., vol. ii, p. 154, and vol. iii, p. 452, appears to have confused several writers. In this country it is first referred to in 1855, in the Missouri report, as *Rhynchonella Missouriensis* Shumard. Only the first of the figures given by Shumard represents this species, as was shown by Mr. Meek, (i. e., Pl. C. fig. 5*a*.)

In 1860, Professor Hall described a form from the Goniatite beds of Indiana, under the name *Rhynchonella* (*Eatonia*) *obsolescens* (13th Rept. on Cabinet N. Y., p. 111). This species cannot be distinguished, so far as the description goes, from the *R. pugnus* Martin, later recognized in the same beds by Meek.

In a paper read before the Iowa Academy of Sciences, in 1877, Prof. S. Calvin described, under the name *Rhynchonella alta*, a species from the Iowa beds. Specimens of this form, lately examined by the author, are identical with the variety of *R. pugnus* met with in the Ithaca beds. This *Rhynchonella* is a peculiar type and is easily distinguished from anything else appearing in the Upper Devonian, or Lower Carboniferous of America.

The representative met with in the High-point beds (Naples, N. Y.), as before mentioned, offers varietal differences in which it approaches the European forms, called *R. acuminata.* One specimen is almost identical with the figure of *R. acuminata* Martin, var. *mesogonia* Phill., given by Davidson on Plate xxi, fig. 3, of his British Carboniferous Brachiopods. It differs from the other representatives of this type before mentioned, in a greater and more angular production of the median fold, and in the sharpness of the plications of this fold, but it differs from the typical *R. acuminata* Martin in the possession of threo distinct, but very short, plications at the margin, outside the median fold, a character distinguishing *R. pugnus* from *R. acuminata.* Of the same type, and it may be same species with above, are *R. Eatoniæformis* McChesney, of the Coal-measures of Illinois, *Terebratula Rocky-montana* and *T. Uta* of Marcou, from the Carboniferous of Salt Lake City, *Rhynchonella Osagensis* Swallow, of the Carboniferous of Missouri, and of Danville, Illinois, and "*Camarophoria globulina* Phillips," as identified by Geinitz, from the Carboniferous at Nebraska City. The typical *R. acuminata* and *R. pugnus* Martin are found associated in British and European Carboniferous beds, and appear in the Devonian.

The American representatives are much smaller than those of the other side of the Atlantic, and, whether we regard them as identical species, or not, there can be no doubt that they are the American representatives of this type.

Now, turning to the Ithaca beds, we find there a fauna, near the base of the Chemung group, in which are species peculiar to the High-point fauna of Ontario Co. and these disputed western deposits, and not known from any other localities in America. These are *Rhynchonella pugnus* Martin, *Productus dissimilis* Hall, *Fistulipora occidens* Hall and *Zaphrentis solida* Hall; and with them, *Cryptonella eudora* Hall occurs in the same

beds, and is so closely related to *C. Calvani* of the Iowa beds that Professor Hall originally referred it to that species.

The association of these peculiar forms in these several localities leads to an overwhelming probability of the actual equivalency of the deposits containing them.

The species of Lime Creek, near Rockford, Iowa, and of High-point, Naples, Ontario county, N. Y., are so strikingly similar that one can scarcely doubt the presence of a common fauna. And the presence in the Ithaca beds, at the same horizon with the High-point beds in Ontario county, of a few of these peculiar forms, persuades us that we are still considering stragglers from the same western fauna, in the very midst of the typical fauna of the Chemung group.

What are the bearings of these facts upon the stratigraphical relations and equivalency of the beds concerned?

In the first place the Ithaca horizon is at a point where we first meet, in ascending, the characteristic Chemung fauna—the first fauna above the Portage group. The higher Chemung fauna, as it appears at Chemung Narrows, N. Y., does not come in to the deposits of this meridian until after the deposition of six hundred feet of coarse sandy shales. The High-point fauna (of Ontario county, N. Y.) is also the earliest Chemung fauna to appear in its meridian; but it is separated from the Genesee slate below by over a thousand feet of deposits of the Portage age, mostly barren shales.

The rocks of Lime Creek, near Rockford, Iowa, as before mentioned, are referred by Professor Hall to the Chemung group, while the western geologists refer them either to the Hamilton group, or to the Kinderhook group which is placed at the base of the Lower Carboniferous. The fauna of these Lime Creek beds has not been met, in its entirety, in any other exposure in the west, but several of its characteristic species appear in the Kinderhook group of Missouri, Indiana and Illinois. The fauna at Ithaca, with which these rare forms are associated, is what is known as the Ithaca fauna, and differs somewhat from the more common and upper fauna of the Chemung group.

Its more common species are:

Strophodonta mucronata,
Spirifer mesocostalis,
Spirifer mesostrialis,
Productella speciosa,
Rhynchonella eximia,
Cryptonella eudora,
Orthis impressa.

The stragglers of the western fauna are rare in these beds, and have been seen in only a few exposures.

In the High-point beds this western fauna appears with scarcely any admixture of typical Chemung species.

The species are as distinct from the ordinary Chemung species of New York as they are from those of the Hamilton group below. Moreover, the High-point fauna contains representatives of nearly every species of mollusca known to be common to the several different exposures of the Kinderhook group in the west.

The corals are not so well represented in the east. A few are seen at the High-point locality, and at Ithaca two specimens have been found which agree, so far as their characters are evident, with *Zaphrentis solida* H. Hall and Whitfield's *Fistulipora occidens* is found in all three localities. It is difficult to explain the numerous coincidences in these three faunas otherwise than by considering them geographical extensions of a single fauna.

The facts of the greater predominance of the Kinderhook fauna in the west and of the Chemung fauna in the east, of the blending of the two in the same strata at Ithaca, of the appearance, at High-point, of the western fauna, nearly distinct, but in a stratum in the midst of typical Portage and Chemung rocks, and of the total absence of the western fauna from most of the Chemung rocks of New York, all tend to the conclusion that the Kinderhook group records a fauna whose geographical center was in the mid-continental area, while the typical fauna of the Chemung group had its geographical center as far east as the Appalachian region. In at least a part of the time when these faunas lived they encroached upon each other.

The rocks at the base of the Chemung group in central New York contain also traces of a recurrent Hamilton fauna, as was shown by the author in 1881 (see Proc. A. A. A. S., vol. xxx). And the species found in this recurrent fauna are mostly among those having a wide geographical range in the Hamilton period. There are also a few forms which began in the lower or middle Devonian, and continued to appear among the species of the Chemung group in New York, in some cases the identical species, in others by varieties of the type.

In the latter case we observe that those modifications which mark the western types of the Hamilton group, as distinguished from the New York Hamilton, are the very peculiarities to distinguish the higher Chemung representatives in New York.

The coarse variety of *Atrypa reticularis*, called *A. aspera* var. *occidentalis* Hall, is a case in point. This and the form called *A. spinosa* are the common forms of the upper Chemung.

Cyrtina Hamiltonensis appears in the western and northwestern Hamilton as a large, coarse form, and with the same modification in the Chemung. Of the *Orthids*, the wider and more gibbous *Orthis impressa*, called *O. Iowensis* in the west, is typical of the Chemung group, and is the western variety.

Strophodonta perplana, var. *nervosa*, and *Strophodonta mucronata* of the Chemung group are much nearer the western *Strophodonta perplana* than the eastern variety of the Hamilton period, and the variety called *Str. canace* of Iowa, in the higher beds, itself appears in the High-point beds of the Chemung.

The common *Str. Cayuta* of the upper Chemung, although quite distinct from the *Str. inæquistriata* of the Hamilton, is apparently only a variety of the western *Str. arcuata.* A like fact may be seen among the Spirifers of the *Sp. mucronatus* type.

The Chemung *Sp. mesocostalis* is easily distinguished from any New York varieties of *Sp. mucronatus.* But the forms met with in the Iowa Hamilton, such as *Sp. submucronatus*, *Sp. bimesialis* and *Sp. inutilis* are intermediate, and approach, at least in the first two "species," the *mesocostalis* type. I also believe that the facts will warrant the generalization that the characteristic species of the Chemung fauna are no more strongly represented in the west than the characteristic Hamilton species are represented in the Chemung rocks of New York.

In New York State the characteristic Chemung fauna appears earliest in the more eastern beds, while in the western part of the State it is only in the middle and upper beds that the fossils appear. These facts suggest the hypothesis that the Chemung fauna came in from the east, and that only the more cosmopolitan forms extended as far west as the mid-continental area; also (2) that the Hamilton fauna had normally a much wider range westward, and (3) was more closely related to the Kinderhook of the west than to the Chemung group of New York.

Finally, I conclude from the study of these several faunas that the deposits of Lime Creek, Rockford, Iowa, and inferentially, all the other beds of the west having a similar fauna, and referred to the Kinderhook group of Meek and Worthen, are geological equivalents of the Chemung period deposits of the east, and not of any eastern lower Carboniferous beds.

This view is in agreement with the original opinions of Professors Hall and Swallow, who referred the Rockford, Iowa, beds and the Chouteau limestone of Missouri to the Chemung period.

There are other reasons, which I cannot here array, for regarding the Rockford, Indiana, Goniatite beds as equivalents of a concretionary limestone of still lower position, in the Portage of New York. To carry the comparison across the ocean, the true equivalents will probably be found in the Pilton and Marwood beds of Devon. While the Genesee slates, passing gradually into the Portage, as they do in Ontario county, New York, with its hard concretionary, calcareous layer, filled with Goniatites, and its *Colcolus aciculum* and *C. tenuicinctum*,

and the characteristic *Cardiola speciosa*, could scarcely be more perfectly represented than by the Domanik schists of Ukta, Russia, with their 'Kalknieren' and the 'Goniatiten Schiefer' of Büdesheim in the Eifel. Their 'Black shales saturated with naphtha,' the 'calcareous concretion,' the 'Goniatites' (the species are closely comparable), the 'slender Orthoceratites,' and the '*Cardium palmatum*' of Goldfuss = *Cardiola retrostriata* Keyserling (the figures of which in Keyserling, Beob., p. 254, t. in fig. 3, or as figured by Roemer, 1876, Taf. 35, fig. 16 *a*, *b*, *c*, *d*, are among the most perfect illustrations I have seen of the common Portage *Cardiola*), and these all leave little doubt as to the close equivalency of the several deposits.

From the above facts it appears reasonable to infer that the Kinderhook group, well developed in the interior of the continent, is represented by a thin wedge at the base of the Chemung period of New York; that the upper Chemung fauna probably did not extend far west of New York State, but if it does appear farther west, it should be looked for in the upper part of, or above the Kinderhook group. So long as the Chemung group is to be retained in the Devonian system, the beds of Lime Creek, Iowa, and their equivalents should be called Devonian. How much of the so-called Kinderhook group this will include must be determined by future investigation. But there can no longer be doubt that there are beds in the interior continental area which are geologically the equivalents of the Chemung period of New York.

ART. IX.—*Contributions to the Geological Chemistry of Yellowstone National Park.*

I. *Geyser waters and deposits;* by HENRY LEFFMANN, M.D.

THE specimens from which the following analyses were made were collected by Dr. A. C. Peale in 1878. Most of the geysers and hot springs are siliceous and produce deposits which vary from hyalite to chalcedony according to age. In most of the waters examined the silica is in the free condition and has been so expressed. All the results are given in grains to the Imperial gallon.

1. *Pearl Geyser.*

Calcium sulphate	1·400
Sodium sulphate	1·890
Sodium chloride	61·390
Silica	7·840
	72·520

At the bottom of the bottle containing this water was a quantity of gelatinous matter looking very much like white of egg. Under the microscope it was entirely structureless, and by heat it dried up to a white opaque mass. Only a small quantity was available for analysis. This was collected on a filter, washed well with distilled water, and then allowed to remain for several weeks in a closed vessel with strong sulphuric acid. It shrank to about one-tenth its volume and became white. It was weighed, heated to redness, weighed again, and then the silica determined by fusion as usual. The results were

Weight before heating	·163 gram.	
Weight after heating	·155 gram = water	4·9%
Silica	·129 gram =	79·1%

Traces of Al_2O_3, Fe_2O_3 and CaO.

The deposit is probably gelatinous silica mixed with some impurities.

2. *Jug Spring.*

Calcium carbonate	0·791
Sodium carbonate	49·140
Sodium sulphate	2·121
Sodium chloride	31·570
Silica	14·560
	98·182

3. *Opal Spring.*—This is not a geyser but a spring having the temperature of 90° F. The water is opalescent; its appearance is exactly like that which is produced by adding an alcoholic solution of rosin to a large volume of water. The opalescence remains for months, even though the water is kept perfectly quiet. On evaporating the water it gelatinizes markedly before it becomes entirely dry.

Sodium chloride	72·180
Calcium sulphate	3·220
Calcium chloride	4·060
Silica	53·760
	143·220

4. *Deposit from Bronze Spring, Shoshone Geyser Basin.*—This deposit is in convoluted layers with bronze-colored surfaces. The powder is fawn-colored. Hardness 5·5.

Silica	83·1
Iron oxide and alumina	1·2
Organic matter and water	13·6

On heating the powder in the drying oven it loses five (5) per cent; a high heat causes it to turn gray, and give out a distinct odor of nitrogenous organic matter. The iron oxide and alumina appear to be in union with the organic matter.

II. *Rocks of the Park;* by WM. BEAM.

The following specimens are from collections made in 1878 by Messrs. Peale and Holmes, geologists to the Hayden Survey. All the rocks so far examined are evidently of igneous origin, and, except the first, are trachytic.

1. *Porphyritic obsidian.*—From the divide between Yellowstone Lake and Upper Geyser Basin of Fire Hole River. Hardness, 6; sp. gr., 2·4. Fracture conchoidal, splintery. Color, greenish black, semi-transparent. Fusibility 4. When heated strongly, swells up to a white blebby mass. With borax on platinum wire, dissolves in large quantity to a clear glass. With microcosmic salt, leaves a skeleton of silica.

Analysis:

SiO_2	77·00%
$Al_2O_3 + Fe_2O_3$*	13·40
CaO	1·25
MgO	1·19
Na_2O	3·43
K_2O	3·62
H_2O (by ignition)	·70
	100·59

2. *Pebble of quartz trachyte covered with a deposit from Echinus Geyser.*—Pebble about one and a half inches in diameter, light fawn in color, and containing small masses of transparent colorless silica. Hardness, 3·5; sp. gr., 2·6. Nearly infusible. Turns white when strongly heated. Gives with borax a clear bead, and with microcosmic salt leaves a skeleton of silica. The powdered mineral is slightly acted upon by hydrochloric acid, and the filtered liquid does not contain any sulphates.

The analysis gave:

SiO_2	77·90
$Al_2O_3 + Fe_2O_3$*	14·55
CaO	·40
MgO	trace
K_2O	4·63
Na_2O	2·10
H_2O (by ignition)	1·00
	100·58

* Very little Fe_2O_3.

Other specimens are being examined and will be reported upon soon.

715 Walnut street, Philadelphia.

ART. X. — *Notes on the Electromagnetic Theory of Light;* by J. WILLARD GIBBS. NO. III. *On the General Equations of Monochromatic Light in Media of every degree of Transparency.*

1. THE last April and June numbers of this Journal* contain an investigation of the velocity of plain waves of light, in which they are regarded as consisting of solenoidal electrical fluxes in an indefinitely extended medium of uniform and very fine-grained structure. It was also supposed that the medium was perfectly transparent, although without discussion of the physical properties on which transparency depends, and that the electrical motions were not complicated by any distinctively magnetic phenomena.

In the present paper† the subject will be treated with more generality, so as to obtain the general equations of monochromatic light for media of every degree of transparency, whether sensibly homogeneous or otherwise, which have a very fine-grained molecular structure as measured by a wave-length of light. There will be no restriction with respect to magnetic influence, except that an oscillating magnetization of the medium will be excluded.‡

In order to conform as much as possible to the ordinary view of electrical phenomena,§ we shall not introduce at first

* See volume xxiii of this Journal, pages 262–275, and 460–476.

† This paper contains, with some additional developments, the substance of a communication to the National Academy of Sciences in November, 1882.

‡ Where a body capable of magnetization is subjected to the influence of light, (as when light is reflected from the surface of iron,) there are two simple hypotheses which present themselves with respect to the magnetic state of the body. One is that the magnetic forces due to the light are not of sufficient duration to allow the molecular changes which constitute magnetization to take place to any sensible extent. The other is that the magnetization has a constant ratio to the magnetic force without regard to its duration. We might easily make a more general hypothesis which would embrace both of those mentioned as extreme cases, and which would be irreproachable from a theoretical stand-point; but it would complicate our equations to a degree which would not be compensated by their greater generality, since no phenomena depending on such magnetization have been observed, so far as the writer is aware, or are likely to be, except in a very limited class of cases.

For the purposes of this paper, therefore, it has seemed better to exclude media capable of magnetization, except so far as the first mentioned hypothesis may be applicable. But it does not appear that this requires us to exclude cases in which the medium is subject to the influence of a permanent magnetic force, such as produces the phenomenon of the magnetic rotation of the plane of polarization.

§ It has, perhaps, retarded the acceptance of the electromagnetic theory of light that it was presented in connection with a theory of electrical action, which is probably more difficult to prove or disprove, and certainly presents more difficulties of comprehension, than the connection of optical and electrical phenomena, and which, as resting largely on *a priori* considerations, must naturally appear very differently to different minds. Moreover, the mathematical method by which the subject was treated, while it will remain a striking monument of its author's originality of thought, and profoundly modify the development of mathe-

the hypothesis of Maxwell that electrical fluxes are solenoidal.* Our results, however, will be such as to require us to admit the substantial truth of this hypothesis, if we regard the processes involved in the transmission of light as electrical.

With regard to the undetermined questions of electrodynamic induction, we shall adopt provisionally that hypothesis which appears the most simple, yet proceed in such a manner that it will be evident exactly how our results must be altered, if we prefer any other hypothesis.

Electrical quantities will be treated as measured in electromagnetic units.

2. We must distinguish, as before, between the *actual* electrical displacements, which are too complicated to follow in detail with analysis, and which in their minutiæ elude experimental demonstration, and the displacements as *averaged* for spaces which are large enough to smooth out their minor irregularities, but not so large as to obliterate to any sensible extent those more regular features of the electrical motion, which form the subject of optical experiment. These spaces must therefore be large as measured by the least distances between molecules, but small as measured by a wave-length of light. We shall also have occasion to consider similar averages for other quantities, as electromotive force, the electrostatic potential, etc. It will be convenient to suppose that the space for which the average is taken is the same in all parts of the field,† say a sphere of uniform radius having its center at the point considered.

Whatever may be the quantities considered, such averages will be represented by the notation

$$[\quad]_{\text{Ave}}$$

If, then, ξ, η, ζ denote the components of the actual displacement at the point considered,

$$[\xi]_{\text{Ave}}, \qquad [\eta]_{\text{Ave}}, \qquad [\zeta]_{\text{Ave}}$$

will represent the average values of these components in the small sphere about that point. These average values we shall

matical physics, must nevertheless, by its wide departure from ordinary methods, have tended to repel such as might not make it a matter of serious study.

*A flux is said to be *solenoidal* when it satisfies the conditions which characterize the motion of an incompressible fluid,—in other words, if u, v, w are the rectangular components of the flux, when

$$\frac{du}{dx} + \frac{dv}{dy} + \frac{dw}{dz} = 0,$$

and the normal component of the flux is the same on both sides of any surfaces of discontinuity which may exist.

† This is rather to fix our ideas, than on account of any mathematical necessity. For the space for which the average is taken may in general be considerably varied without sensibly affecting the value of the average.

treat as functions of the coördinates of the center of the sphere and of the time, and may call them, for brevity, the *average values* of ξ, η, ζ. But however they may be designated, it is essential to remember that it is a space-average for a certain very small space, and never a time-average, that is intended.

The object of this paper will be accomplished when we have expressed (explicitly or implicitly), the relations which subsist between the values of $[\xi]_{\text{Ave}}$, $[\eta]_{\text{Ave}}$, $[\zeta]_{\text{Ave}}$, at different times and in different parts of the field,—in other words, when we have found the conditions which these quantities must satisfy as functions of the time and the coördinates.

3. Let us suppose that luminous vibrations of any one period* are somewhere excited, and that the disturbance is propagated through the medium. The motions which are excited in any part of the medium, and the forces by which they are kept up, will be expressed by harmonic functions of the time, having the same period,† as may be proved by the single principle of the superposition of motions, quite independently of any theory of the constitution of the medium, or of the nature of the motions, as electrical or otherwise. This is equally true of the actual motions, and of the averages which we are to consider. We may therefore set

$$\left.\begin{aligned}[\xi]_{\text{Ave}} &= a_1 \cos \frac{2\pi}{p}t + a_2 \sin \frac{2\pi}{p}t,\\ &\text{etc.,}\end{aligned}\right\} \qquad (1)$$

where t denotes the time, p the period, and a_1, a_2, functions of the coördinates. It follows that

$$\left.\begin{aligned}[\ddot{\xi}]_{\text{Ave}} &= -\frac{4\pi^2}{p^2}[\xi]_{\text{Ave}},\\ &\text{etc.}\end{aligned}\right\} \qquad (2)$$

* There is no real loss of generality in making the light monochromatic, since in every case it may be divided into parts, which are separately propagated, and each of which is monochromatic to any required degree of approximation.

† It is of course possible that the expressions for the forces and displacements should have constant terms. But these will disappear, if the displacements are measured from the state of equilibrium about which the system vibrates, and we leave out of account in measuring the forces (and the electrostatic potential) that which would belong to the system in the state of equilibrium. To prevent misapprehension, it should be added that the term *electrical displacement* is *not* used in the restricted sense of *dielectric displacement* or *polarization*. The variation of the electrical displacement, as the term is used in this paper, constitutes what Maxwell calls the total motion of electricity or true current, and what he divides into two parts, which he distinguishes as the current of conduction and the variation of the electrical displacement. Such a division of the total motion of electricity is not necessary for the purposes of this paper, and the term displacement is used with reference to the total motion of electricity in a manner entirely analogous to that in which the term is ordinarily used in the theory of wave-motion.

4. Now, on the electrical theory, these motions are excited by electrical forces, which are of two kinds, distinguished as electrostatic and electrodynamic. The electrostatic force is determined by the electrostatic potential. If we write q for the actual value of the potential, and $[q]_{\text{Ave}}$ for its value as averaged in the manner specified above, the components of the actual electrostatic force will be

$$-\frac{dq}{dx}, \qquad -\frac{dq}{dy}, \qquad -\frac{dq}{dz};$$

and for the average values of these components in the small spaces described above we may write

$$-\frac{d[q]_{\text{Ave}}}{dx}, \qquad -\frac{d[q]_{\text{Ave}}}{dy}, \qquad -\frac{d[q]_{\text{Ave}}}{dz},$$

for it will make no difference whether we take the average before or after differentiation.

5. The electrodynamic force is determined by the acceleration of electrical flux in all parts of the field, but physicists are not entirely agreed in regard to the laws by which it is determined. This difference of opinion is however of less importance, since it will not affect the result if electrical fluxes are always solenoidal. According to the most simple law, the components of the force are given by the volume-integrals

$$-\iiint \frac{\ddot{\xi}}{r}\,dv, \qquad -\iiint \frac{\ddot{\eta}}{r}\,dv, \qquad -\iiint \frac{\ddot{\zeta}}{r}\,dv,$$

where dv represents an element of volume, and r the distance of this element from the point for which the value of the electromotive force is to be determined. In other words, the components of the force at any point are determined from the components of acceleration in all parts of the field by the same process by which (in the theories of gravitation, etc.,) the value of the potential at any point is determined from the density of matter in all parts of space, except that the sign is to be reversed. Adopting this law provisionally, at least, we may express it by saying that the components of electrodynamic force are equal to the potentials taken negatively of the components of acceleration of electrical flux. And we may write, for brevity,

$$-\operatorname{Pot}\ddot{\xi}, \qquad -\operatorname{Pot}\ddot{\eta}, \qquad -\operatorname{Pot}\ddot{\zeta},$$

for the components of force, using the symbol *Pot* to denote the operation by which the potential of a mass is derived from its density. For the average values of these components in the small spaces defined above, we may write

$$-\operatorname{Pot}[\ddot{\xi}]_{\text{Ave}}, \qquad -\operatorname{Pot}[\ddot{\eta}]_{\text{Ave}}, \qquad -\operatorname{Pot}[\ddot{\zeta}]_{\text{Ave}}$$

since it will make no difference whether we take the average before or after the operation of taking the potential.

6. If we write X, Y, Z for the components of the total electromotive force (electrostatic and electrodynamic), we have

$$\left.\begin{array}{l}[X]_{\text{Ave}} = -\operatorname{Pot}[\ddot{\xi}]_{\text{Ave}} - \dfrac{d[q]_{\text{Ave}}}{dx}, \\ \quad\text{etc.};\end{array}\right\} \tag{3}$$

or by (2)

$$\left.\begin{array}{l}[X]_{\text{Ave}} = \dfrac{4\pi^2}{p^2}\operatorname{Pot}[\xi]_{\text{Ave}} - \dfrac{d[q]_{\text{Ave}}}{dx}, \\ \quad\text{etc.}\end{array}\right\} \tag{4}$$

It will be convenient to represent these relations by a vector notation. If we represent the displacement by $\mathfrak{U}$, and the electromotive force by $\mathfrak{E}$, the three equations of (3) will be represented by the single vector equation

$$[\mathfrak{E}]_{\text{Ave}} = -\operatorname{Pot}[\ddot{\mathfrak{U}}]_{\text{Ave}} - \nabla[q]_{\text{Ave}}, \tag{5}$$

and the three equations of (4) by the single vector equation

$$[\mathfrak{E}]_{\text{Ave}} = \frac{4\pi^2}{p^2}\operatorname{Pot}[\mathfrak{U}]_{\text{Ave}} - \nabla[q]_{\text{Ave}}, \tag{6}$$

where, in accordance with quaternionic usage, $\nabla[q]_{\text{Ave}}$ represents the vector which has for components the derivatives of $[q]_{\text{Ave}}$ with respect to rectangular coördinates. The symbol *Pot* in such a vector equation signifies that the operation which is denoted by this symbol in a scalar equation is to be performed upon each of the components of the vector.

7. We may here observe that if we are not satisfied with the law adopted for the determination of electrodynamic force, we have only to substitute for $-$*Pot* in these vector equations, and in those which follow, the symbol for the operation, whatever it may be, by which we calculate the electrodynamic force from the acceleration.* For the operation must be of such a character, that if the acceleration consist of any number of parts, the force due to the whole acceleration will be the resultant of the forces due to the separate parts. It will evidently make no difference whether we take an average before or after such an operation.

8. Let us now examine the relation which subsists between the values of $[\mathfrak{E}]_{\text{Ave}}$ and $[\mathfrak{U}]_{\text{Ave}}$ for the same point, that is, between the average electromotive force and the average displacement in a small sphere with its center at the point consid-

* The same would not be true of the corresponding scalar equations, (3) and (4). For one component of the force might depend upon all the components of acceleration. Such is in fact the case with the law of electromotive force proposed by Weber.

ered. We have already seen that the forces and the displacements are harmonic functions of the time having a common period.

A little consideration will show that if the average electromotive force in the sphere is given as a function of the time, the displacements in the sphere, both average and actual, must be entirely determined. Especially will this be evident, if we consider that since we have made the radius of the sphere very small in comparison with a wave-length, the average force must have sensibly the same value throughout the sphere, (that is, if we vary the position of the center of the sphere for which the average is taken by a distance not greater than the radius, the value of the average will not be sensibly affected,) and that the difference of the actual and average force at any point is entirely determined by the motions in the immediate vicinity of that point. If, then, certain oscillatory motions may be kept up in the sphere under the influence of electrostatic and electrodynamic forces due to the motion in the whole field, and if we suppose the motions in and very near that sphere to be unchanged, but the motions in the remoter parts of the field to be altered, only not so as to affect the average resultant of electromotive force in the sphere, the actual resultant of electromotive force will also be unchanged throughout the sphere, and therefore the motions in the sphere will still be such as correspond to the forces.

Now the average displacement is a harmonic function of the time having a period which we suppose given. It is therefore entirely determined for the whole time the vibrations continue by the values of the six quantities

$$[\xi]_{\text{Ave}},\quad [\eta]_{\text{Ave}},\quad [\zeta]_{\text{Ave}},\quad [\dot{\xi}]_{\text{Ave}},\quad [\dot{\eta}]_{\text{Ave}},\quad [\dot{\zeta}]_{\text{Ave}}$$

at any one instant. For the same reason the average electromotive force is entirely determined for the whole time by the values of the six quantities

$$[X]_{\text{Ave}},\quad [Y]_{\text{Ave}},\quad [Z]_{\text{Ave}},\quad [\dot{X}]_{\text{Ave}},\quad [\dot{Y}]_{\text{Ave}},\quad [\dot{Z}]_{\text{Ave}}$$

for the same instant. The first six quantities will therefore be functions of the second, and the principle of the superposition of motions requires that they shall be homogeneous functions of the first degree. And the second six quantities will be homogeneous functions of the first degree of the first six. The coefficients by which these functions are expressed will depend upon the nature of the medium in the vicinity of the point considered. They will also depend upon the period of vibration, that is, upon the color of the light.*

* The relations between the displacements in one of the small spaces considered and the average electromotive force is mathematically analogous to the relation between the displacements in a system of a high degree of complexity and certain forces exerted from without, which are harmonic functions of the time and under

We may therefore write in vector notation

$$[\mathsf{E}]_{\text{Ave}} = \Phi[\mathsf{U}]_{\text{Ave}} + \Psi[\dot{\mathsf{U}}]_{\text{Ave}} \qquad (7)$$

where Φ and Ψ denote linear functions.*

The optical properties of media are determined by the form of these functions. But all forms of linear functions would not be consistent with the principle of the conservation of energy.

In media which are more or less opaque, and which therefore absorb energy, Ψ must be of such a form that the function always makes an acute angle (or none) with the independent variable. In perfectly transparent media Ψ must vanish, unless the function is at right angles to the independent variable. So far as is known, the last occurs only when the medium is subject to magnetic influence. In perfectly transparent media, the principle of the conservation of energy requires that Φ should be self-conjugate, *i. e.*, that for three directions at right angles to one another, the function and independent variable should coincide in direction.

In all isotropic media not subject to magnetic influence, it is probable that Φ and Ψ reduce to numerical coefficients, as is certainly the case with Φ for transparent isotropic media.

9. Comparing the two values of $[\mathsf{E}]_{\text{Ave}}$, we have

$$\frac{4\pi^2}{p^2}\,\text{Pot}\,[\mathsf{U}]_{\text{Ave}} - \nabla[q]_{\text{Ave}} = \Phi[\mathsf{U}]_{\text{Ave}} + \Psi[\dot{\mathsf{U}}]_{\text{Ave}}. \qquad (8)$$

This equation, in connection with that by which we express the solenoidal character of the displacements, if we regard them as necessarily solenoidal, or in connection with that which expresses the relation between the electrostatic potential and the displacements, if we reject the solenoidal hypothesis, may be regarded as the general equation of the vibrations of monochromatic light, considered as oscillating electrical fluxes. For the symbol *Pot*, however, we must substitute the symbol representing the operation by which electromotive force is calculated from acceleration of flux, with the negative sign, if we are not satisfied with the law provisionally adopted.

It is important to observe that the existence of molecular vibrations of ponderable matter, due to the passage of light through the medium, will not affect the reasoning by which this equation has been established, provided that the nature

the influence of which the system vibrates. The ratio of the displacements to the forces will in general vary with the period, and may vary very rapidly.

An example in which these functions vary very rapidly with the period is afforded by the phenomena of selective absorption and abnormal dispersion.

* A vector is said to be a linear function of another, when the three component of the first are homogeneous functions of the first degree of the three component of the second.

and intensity of these vibrations in any small part of the medium (as measured by a wave-length) are entirely determined by the electrical forces and motions in that part of the medium. But the equation would not hold in case of molecular vibrations due to magnetic force. Such vibrations would constitute an oscillating magnetization of the medium, which has already been excluded from the discussion.

The supposition which has sometimes been made,* that electricity possesses a certain mass or inertia, would not at all affect the validity of the equation.

10. The equation may be reduced to a form in some respects more simple by the use of the so-called imaginary quantities. We shall write ι for $\sqrt{(-1)}$. If we differentiate with respect to the time, and substitute $-\frac{4\pi^2}{p^2}[\dot{\mathsf{U}}]_{\text{Ave}}$ for $[\dddot{\mathsf{U}}]_{\text{Ave}}$, we obtain

$$\frac{4\pi^2}{p^2}\,\text{Pot}\,[\dot{\mathsf{U}}]_{\text{Ave}} - \nabla[\dot{q}]_{\text{Ave}} = \Phi[\dot{\mathsf{U}}]_{\text{Ave}} - \frac{4\pi^2}{p^2}\,\Psi[\mathsf{U}]_{\text{Ave}}$$

If we multiply this equation by ι, either alone or in connection with any real factor, and add it to the preceding, we shall obtain an equation which will be equivalent to the two of which it is formed. Multiplying by $-\frac{p\iota}{2\pi}$ and adding, we have

$$\frac{4\pi^2}{p^2}\,\text{Pot}\left([\mathsf{U}]_{\text{Ave}} - \iota\frac{p}{2\pi}[\dot{\mathsf{U}}]_{\text{Ave}}\right) - \nabla\left([q]_{\text{Ave}} - \iota\frac{p}{2\pi}[\dot{q}]_{\text{Ave}}\right)$$
$$= \left(\Phi + \iota\frac{2\pi}{p}\,\Psi\right)\left([\mathsf{U}]_{\text{Ave}} - \iota\frac{p}{2\pi}[\dot{\mathsf{U}}]_{\text{Ave}}\right).$$

If we set

$$\mathsf{W} = [\mathsf{U}]_{\text{Ave}} - \iota\frac{p}{2\pi}[\dot{\mathsf{U}}]_{\text{Ave}}, \tag{9}$$

$$\mathsf{Q} = [q]_{\text{Ave}} - \iota\frac{p}{2\pi}[\dot{q}]_{\text{Ave}}, \tag{10}$$

$$\Theta = \Phi + \iota\frac{2\pi}{p}\,\Psi, \tag{11}$$

our equation reduces to

$$\frac{4\pi^2}{p^2}\,\text{Pot}\,\mathsf{W} - \nabla\mathsf{Q} = \Theta\mathsf{W}. \tag{12}$$

In this equation Θ denotes a complex linear vector function, *i. e.*, a vector function of which the X-, Y-, and Z-components are expressed in terms of the X-, Y-, and Z-components of the independent variable by means of coëfficients of the form $a+\iota b$. $\underline{\mathsf{W}}$ is a bi-vector of which the real part represents the

* See Weber, Abhandl. d. K. Sächs. Gesellsch. d. Wiss., vol. vi, p. 593–597; Lorberg, Crelle's Journal, vol. lxi, p. 55.

averaged displacement $[\mathbf{U}]_{\text{Ave}}$, and the coefficient of ι the rate of increase of the same multiplied by a constant factor. This bi-vector therefore represents the average state of a small part of the field both with respect to position and velocity. We may also say that the coefficient of ι in $\mathbf{W}$ represents the value of the averaged displacement $[\mathbf{U}]_{\text{Ave}}$ at a time one-quarter of a vibration earlier than the time principally considered.

11. It may serve to fix our ideas to see how $\mathbf{W}$ is expressed as a function of the time. We may evidently set

$$[\mathbf{U}]_{\text{Ave}} = \mathbf{A}_1 \cos \frac{2\pi}{p} t + \mathbf{A}_2 \sin \frac{2\pi}{p} t$$

where $\mathbf{A}_1$ and $\mathbf{A}_2$ are vectors representing the amplitudes of the two parts into which the vibration is resolved. Then

$$\frac{p}{2\pi} [\dot{\mathbf{U}}]_{\text{Ave}} = - \mathbf{A}_1 \sin \frac{2\pi}{p} t + \mathbf{A}_2 \cos \frac{2\pi}{p} t,$$

and

$$[\mathbf{U}]_{\text{Ave}} - \iota \frac{p}{2\pi} [\dot{\mathbf{U}}]_{\text{Ave}} = (\mathbf{A}_1 - \iota\, \mathbf{A}_2) \left(\cos \frac{2\pi}{p} t + \iota \sin \frac{2\pi}{p} t\right);$$

that is, if we set $\mathbf{A}=\mathbf{A}_1 - \iota \mathbf{A}_2$,

$$\mathbf{W} = \mathbf{A}\, e^{\frac{2\pi \iota t}{p}}. \tag{13}$$

In like manner we may obtain

$$\mathbf{Q} = g\, e^{\frac{2\pi \iota t}{p}}, \tag{14}$$

where g is a bi-scalar, or complex quantity of ordinary algebra. Substituting these values in (12), and cancelling the common factor containing the time, we have

$$\frac{4\pi^2}{p^2} \text{Pot}\, \mathbf{A} - \nabla g = \Theta \mathbf{A}. \tag{15}$$

Our equation is thus reduced to one between $\mathbf{A}$ and g, and may easily be reduced to one in $\mathbf{A}$ alone.* Now $\mathbf{A}$ represents six numerical quantities, (viz: the three components of $\mathbf{A}_1$, and the three of $\mathbf{A}_2$), which may be called the six components of amplitude. The equation, therefore, substantially represents the relations between the six components of amplitude in different parts of the field.† The equation is, however, not really

* The terms $\nabla \mathbf{Q}$, ∇q are allowed to remain in these equations, because the best manner of eliminating them will depend somewhat upon our admission or rejection of the solenoidal hypothesis.

† The representation of the six components of amplitude by a single letter should not be regarded as an analytical artifice. It only leaves undivided in our notation that which is undivided in the nature of things. The separation of the six components of amplitude is artificial, in that it introduces arbitrary elements into the discussion, viz: the directions of the axes of the coördinates, and the zero of time.

different from (12), since $\mathbf{A}$ and g are only particular values of $\mathbf{W}$ and Q.

12. From the general equation given above (8, 12, or 15), in connection with the solenoidal hypothesis, we may easily derive the laws of the propagation of plane waves in the interior of a sensibly homogeneous medium, and the laws of reflection and refraction at surfaces between such media. This has been done by Maxwell,* Lorentz,† and others,‡ with fundamental equations more or less similar.

The method, however, by which the fundamental equation has been established in this paper seems free from certain objections which have been brought against the ordinary form of the theory. As ordinarily treated, the phenomena are made to depend entirely on the inductive capacity and the conductivity of the medium, in a manner which may be expressed by the equation

$$[\mathbf{U}]_{\text{Ave}} = \left(\frac{\text{K}}{4\pi} - \frac{p^2\text{C}}{4\pi^2}\frac{d}{dt}\right)\left(\frac{4\pi^2}{p^2}\text{Pot}\,[\mathbf{U}]_{\text{Ave}} - \nabla[q]_{\text{Ave}}\right), \qquad (16)$$

which will be equivalent to (12), if

$$\mathbf{W} = \left(\frac{\text{K}}{4\pi} - \iota\frac{p\text{C}}{2\pi}\right)\left(\frac{4\pi^2}{p^2}\text{Pot}\,\mathbf{W} - \nabla\text{Q}\right), \qquad (17)$$

where K and C denote in the most general case the linear vector functions, but in isotropic bodies the numerical coëfficients, which represent inductive capacity and conductivity. By a simple transformation [see (9) and (10)], this equation becomes

$$\Theta^{-1} = \frac{\text{K}}{4\pi} - \iota\frac{p\text{C}}{2\pi}, \qquad (18)$$

where Θ^{-1} represents the function inverse to Θ.

Now, while experiment appears to verify the existence o such a law as is expressed by equation (12), it does not show that Θ has the precise form indicated by equation (16). In other words, experiment does not satisfactorily verify the relations expressed by (16) and (17), if K and C are understood to be the operators (or, in isotropic bodies, the numbers) which represent induction capacity and conductivity in the ordinary sense of the terms.

* Phil. Trans., vol. clv (1865), p. 459, or *Treatise on Electricity and Magnetism*, Chap. XX.

† Schlömilch's Zeitschrift, vol. xxii, pp. 1-30 and 205–219; xxiii, pp. 197–210.

‡ See Fitzgerald, Phil. Trans., vol. clxxi, p. 691; J. J. Thomson, Phil. Mag., V, vol. ix, p. 284; Rayleigh, Phil. Mag., V, vol. xii, p. 81.

That the electromagnetic theory of light gives the conditions relative to the boundary of different media, which are required by the phenomena of reflection and refraction, was first shown by Helmholtz. See Crelle's Journal, vol. lxxii (1870), p. 57.

The discrepancy is most easily shown in the most simple case, when the medium is isotropic and perfectly transparent, and θ reduces to a numerical quantity. The square of the velocity of plane waves is then equal to $\frac{\Theta}{4\pi}$, and equation (18) would make it independent of the period; that is, would give no dispersion of colors. The case is essentially the same in transparent bodies which are not isotropic.*

The case is worse with metals, which are characterized electrically by great conductivity, and optically by great opacity. In their papers cited above, Lorentz and Rayleigh have observed that the experiments of Jamin on the reflection of light from metallic surfaces would often require, as ordinarily interpreted on the electro-magnetic theory, a negative value for the inductive capacity of the metal. This would imply that the electrical equilibrium in the metal is unstable. The objection, therefore, is essentially the same as that which Lord Rayleigh had previously made to Cauchy's theory of metallic reflection, viz: that the apparent mechanical explanation of the phenomena is illusory, since the numerical values given by experiment as interpreted on Cauchy's theory would involve an unstable equilibrium of the ether in the metal.†

13. All this points to the same conclusion—that the ordinary view of the phenomena is inadequate. The object of this paper will be accomplished, if it has been made clear, how a point of view more in accordance with what we know of the molecular constitution of bodies will give that part of the ordinary theory which is verified by experiment, without including that part which is in opposition to observed facts.‡

* See note to the first paper of Lorentz, cited above, Schlömilch, vol. xxii, p. 23.

† See Phil. Mag., IV, vol. xliii (1872), p. 321.

‡ The consideration of the processes which we may suppose to take place in the smallest parts of a body through which light is transmitted, farther than is necessary to establish the general equation given above, is foreign to the design of this paper. Yet a word may be added with respect to the difficulties signalized in the ordinary form of the theory. The comparatively simple case of a perfectly transparent body has been examined more in detail in one of the papers already cited, where there is given an explanation of the dispersion of colors from the point of view of this paper. It is there shown that the effect of the non-homogenity of the body in its smallest parts is to add a term to the expression for the kinetic energy of electrical waves, which for an isotropic body may be roughly described as similar to that which would be required if the electricity had a certain mass or inertia. (See especially §§ 7, 9 and 12, pages 266 ff. of volume xxiii of this Journal.) The same must be true of media of any degree of opacity. Now the difficulty with the optical properties of the metals is that the real part of Θ (or Θ^{-1}) is in some cases negative. This implies that at a moment of greatest displacement the electromotive force is in the direction opposite to the displacement, instead of having the same direction, as in transparent isotropic bodies. Now a certain part of the electromotive force must be required to oppose the apparent inertia, and another part to oppose the electrical elasticity of the medium. These parts of the force must have opposite directions. In transparent

While the writer has aimed at a greater degree of rigor than is usual in the establishment of the fundamental equation of monochromatic light, it is not claimed that this equation is absolutely exact. The contrary is evident from the fact that the equation does not embrace the phenomena which characterize such circularly polarizing bodies as quartz. This, however, only implies the neglect of extremely small quantities—very small, for example, as compared with those which determine the dispersion of colors. In one of the papers already cited,* the case of a perfectly transparent body is treated with a higher degree of approximation, so as to embrace the phenomena in question.

ART. XI.—*The Rainfall in Middletown, Connecticut, from* 1859 *to* 1882; by HENRY D. A. WARD.

WHEN Mr. B. F. Harrison's paper, on the Rainfall in Wallingford, appeared in the American Journal of Science in June, 1881, a friend suggested that the publication of a similar one from my own records would be of interest as affording a means of comparing the precipitation of the two places.

As a result of this suggestion the following table has been prepared. It covers a period of twenty-four years, from January 1st, 1859 to December 31st, 1882, and, like Mr. Harrison's, gives month by month the amount of rain and melted snow, and the depth of snow. Middletown is in latitude 41° 33′ N. and longitude 72° 39′ W., and is about ten miles northeast of Wallingford, on the eastern declivity of the range of hills on whose western slope that town is situated.

I deem it proper to state that, up to June 1st, 1868, the observations were made by the late Professor Johnston of the Wesleyan University, at an elevation of some 175 feet above sea-level. Since that time they have been made by myself, at a station about a quarter of a mile from Professor Johnston's and 70 feet above sea-level.

bodies the latter part is by far the greater. But it need not surprise us that the former should be the greater in some metals.

It has been remarked by Lorentz that the difficulty with respect to metals would be in a measure relieved if we should suppose electricity to have the property of inertia. (See § 11 of his third paper, Schlömilch's Zeitschrift, vol. xxiii, p. 208.) But a supposition of this kind, taken literally, would involve a dispersion of colors in vacuo, and still be inadequate, as Lorentz remarks, to explain the phenomena observed in metals.

* See volume xxiii of this Journal, page 460.

	January.		February.		March.		April.		May.		June.	July.	Aug'st	Sept.	October.		November.		December.		Year.	
	Rain.	Snow.	Rain.	Snow.	Rain.	Snow.	Rain.	Snow.	Rain.	Snow.	Rain.	Rain.	Rain.	Rain.	Rain.	Snow.	Rain.	Snow.	Rain.	Snow.	Rain.	Snow.
1859	7·18	28·00	4·20	23·00	7·52	12·00	3·06	0·00	4·18	--	6·09	2·17	6·57	3·90	2·13	--	2·45	--	3·88	9·00	53·33	72·00
1860	1·69	10·00	2·62	18·00	1·68	0·00	1·71	3·00	3·86	--	3·14	2·76	3·70	3·70	2·56	--	4·74	--	5·23	11·00	37·39	42·00
1861	4·13	13·00	2·68	3·00	4·22	20·00	4·97	9·00	6·82	--	3·65	3·54	6·09	3·88	2·20	--	3·28	5·00	1·57	4·00	47·03	54·00
1862	5·21	4·00	2·14	19·00	3·87	3·00	1·59	0·00	2·37	--	8·05	6·24	1·65	5·45	3·94	--	5·79	3·00	1·73	16·00	48·03	45·00
1863	4·24	4·00	5·11	17·00	4·73	20·00	4·26	2·00	1·74	--	1.01	11·14	4·90	1·73	3·34	--	5·02	0·00	5·25	11·00	52·47	54·00
1864	3·07	5·00	1·40	9·50	2·06	5·00	1·82	0·00	3·82	--	3·00	1·68	2·92	3·45	2·66	-	4·13	2·00	3·99	19·00	34·00	40·50
1865	4·16	11·00	3·61	8·00	4·75	2·00	3·41	1·00	6·85	--	2·41	4·65	1·85	0·75	3·21	--	3·96	0·00	2·99	12·00	42·60	34·00
1866	1·61	16·00	5·11	0·00	2·60	0·00	2·90	0·00	5·38	--	3·02	4·04	4·24	6·74	2·98	--	4·34	0·00	3·31	10·00	46·27	26·00
1867	2·41	28·00	4·34	12·00	3·51	17·50	2·44	0·00	4·53	--	5·39	3·31	10·22	2·83	4·12	--	2·75	12·00	2·49	14·00	48·34	83·50
1868	3·36	27·00	1·53	12·00	2·78	17·00	4·48	14·00	7·63	--	5·24	2·36	7·39	10·49	0·89	--	4·00	0·00	2·39	11·50	52·54	81·50
1869	3·17	7·00	5·04	15·00	7·51	7·50	1·95	0·00	6·05	--	5·38	2·96	2·80	3·90	15·54	--	3·34	1·00	6·33	13·00	63·97	43·50
1870	5·72	3·00	5·45	14·00	5·97	18·00	5·32	0·00	1·74	--	2·73	1·42	3·29	1·33	4·23	--	3·08	0·00	2·30	4·00	42·58	39·00
1871	3·43	22·00	4·10	22·00	6·52	1·00	3·14	4·00	4·80	--	4·24	5·48	8·02	1·94	3·69	--	4·51	0·00	3·31	9·25	53·18	58·25
1872	2·19	1·25	2·87	12·00	4·02	12·75	1·95	0·00	3·09	--	4·89	5·43	5·58	4·94	2·47	--	5·08	6·50	4·08	28·00	46·59	60·50
1873	6·79	13·00	3·03	18·00	2·95	1·00	3·16	1·00	4·25	--	0·46	2·09	8·31	2·37	6·18	--	4·29	3·00	5·06	22·25	48·94	58·25
1874	5·98	10·75	3·69	23·00	1·45	5·00	7·11	2·25	3·48	--	2·21	5·78	6·30	2·82	1·44	--	2·64	1·00	2·31	8·50	45·21	50·50
1875	2·86	11·50	4·86	9·50	5·18	31·50	3·89	16·00	1·44	--	3 25	2·49	5·64	1·59	4·56	--	5·73	0·50	1·20	1·00	42·69	70·00
1876	1·45	5·00	5·11	14·00	9·49	8·00	3·71	4·00	2·87	2·00	1·89	10·20	1·23	6·04	1·16	1·00	4·05	0·50	4·21	26·75	51·41	61·25
1877	3·38	18·00	1·14	2·00	9·24	3·00	2·60	0·00	1·11	--	6·58	2·99	6·15	0·94	9·11	--	7·29	0·00	1·56	0·00	52·09	23·00
1878	5·77	11·00	5·13	2·00	2·89	0·00	4·42	0·00	2·93	--	3·68	1·99	4·89	1·80	2·74	--	5·48	0·50	7·91	6·50	49·63	20·00
1879	2·49	17·50	4·07	15·00	5·53	10·50	5·95	2·75	2·69	--	4·38	5·88	8·24	1·88	1·18	--	1·78	1·00	3·84	8·25	47·91	55·00
1880	3·50	5·00	3·68	8·50	3·51	10·50	3·80	0·00	0·74	--	3·07	5·67	5·56	4·13	3·94	--	2·28	1·00	2·92	18·00	42·80	43·00
1881	5·17	17·00	6·15	11·00	6·42	4·00	1·74	2·00	4·57	--	3·55	2·84	2·87	0·49	2·41	--	4·50	1·00	4·19	1·50	44·90	36·50
1882	5·12	27·00	4·74	22·00	3·64	2·00	1·48	1·00	4·38	--	1·96	2·17	1·25	11·64	4·69	--	1·65	16·00	2·65	8·50	45·37	76·50
Tot'l	94·08	315·00	91·80	309·50	112·04	211·25	80·86	62·00	91·32	2·00	89·27	99·28	119·66	88·73	91·37	1·00	96·16	54·00	84·70	273·00	1139·27	1227·75
Ave.	3·920	13·125	3·825	12·896	4·668	8·802	3·369	2·583	3·805	0·083	3·719	4·136	4·986	3·697	3·807	0·041	4·006	2·250	3·529	11·375	47·47	51·16

ART. XII.—*New Discoveries in Devonian Crustacea;* by JOHN M. CLARKE.

IN continuation of the notice of some new Devonian Crustacea which was published in this Journal for June, 1882 (3d ser., vol. xxiii, p. 476), I have to add a description of some new and extremely interesting forms allied to those there noticed, with a few remarks on their affinities and distribution. The species there described as *Spathiocaris Emersonii* appears on more careful investigation to have an unusual and remarkable vertical range through the rocks of the Chemung Period. The original examples were found in considerable abundance in the Portage shales, in the town of Naples, Ontario Co., N. Y., but at the time of description were confined, as far as my knowledge went, almost exclusively to one stratum, 550 feet above the top of the "Transition shales,"* between the Genesee and Portage.

My companion in the field, Mr. D. D. Luther, and myself have, during the past summer, found the fossil with the following distribution:

1. In the "Lower Black Band" of the Portage, 50 feet above the "Transition shales," Bristol, Ontario Co.
2. About 150 feet above the "Transition shales," in the town of Naples.
3. Approximately the same horizon in the town of Richmond, Ontario Co.
4. In the "Upper Black Band" of the Portage, 540 feet above the "Transition shales," Naples.
5. In approximately the same horizon, in the "Upper Black Band," $1\frac{1}{2}$ miles south of the Shaker Settlement, along Cashaqua Creek, Livingston Co.
6. In approximately the same horizon in a cut on the Delaware, Lackawanna & Western R. R., in the town of Sparta, Livingston Co.
7. In the shales immediately overlying 4.
8. In the Upper Portage sandstones, Portageville, Wyoming County.

* The term "Transition shales" is applied without liability to misinterpretation to passage beds of slightly arenaceous shales lying between the highest horizon of the fossils belonging distinctively to the Genesee, and the lowest stratum of undoubted Portage age. These beds measure usually between 30 and 60 feet and have a wide distribution in the counties of Ontario, Yates, Livingston, and I believe them to be well defined on the Genesee River at Mt. Morris. They contain a fauna which is a commingling of these fossils: *Cardiola speciosa* H., a lamellibranch diagnostic of the Portage, *Lunulacardium fragile* H., equally diagnostic of the Genesee, with *Coleolus aciculum* H., of the Portage, *Goniatites complanatus* H., of the Hamilton and Portage, *Styliola fissurella* H., abundant from the base of the Hamilton to the base of the Chemung proper, and a *Pleurotomaria* of undescribed species, abundant in the Portage.

9. In the lowest stratum of the Chemung proper, Naples.
10. In the sandstones of the Lower Chemung in the town of Canadice, Ontario Co.

This very wide range of *Spathiocaris Emersonii* without specific variation is the more remarkable on account of the complete differences in the character of the faunæ of which it makes a part in the different strata. In the lower muddy shales, its associates are the more commonly occurring fossils of the Portage rocks, *Goniatites complanatus* H., *Coleolus aciculum* H., *Cardiola speciosa* H., *Lunulacardium ornatum* H., *Cardiomorpha* (*Paracyclas*) *suborbicularis* H. In the bituminous shales of the "Upper Black Band," it appears with remains of the genus *Paleoniscus* and other undetermined fish relics, and also with an abundance of plant remains of doubtful affinities, spores of ferns or Lycopods, and with "Conodonts" and Annelidan teeth; in the Chemung in the lowest horizon with *Leiorhynchus mesacostalis* Hall, and in the upper only with crustacean forms allied to itself, presently to be described. Such a capability of adaptation to environments so markedly different, a muddy or a sandy sea-bottom, or an in-shore, brackish water swamp, such as might have produced the bituminous shales, or if we accept Newberry's suggestion a deep-water, sub-sargossan bottom, and all this without any apparent specific variation, is highly interesting, for in the modern allies of these Crustacea we find a very marked susceptibility to such changes.

I have in my possession a number of fragmentary and ill-defined crustacean remains from the same beds with these fossils, some of which have more or less resemblance to, and may prove to be, abdominal segments, but I should hesitate to describe any as such.

I have discovered another variation from the type of *Spathiocaris* in certain specimens taken from the shales and sandstones of the Chemung proper, at several localities, and in one, Canadice, Ontario Co., associated with *Spathiocaris Emersonii*, with which it is allied in some points of the structure of the carapace. The differences are, however, very strongly defined and generic, as will be readily seen from this diagnosis of the genus.

DIPTEROCARIS (*δίπτερος*=two-winged, *χαρίς*= a prawn).

Carapace in one piece, elongate, divided along the major axis into two more or less separated wings or *alæ*. Greatest width anteriorly through the apex or area of union of the *alæ* of the carapace. These *alæ* approach each other in planes which, normally, make an angle of about 120°, but the area of union is not acute but rounded. *Alæ* united medially for a distance equal to ⅓d or ¼th the length of the carapace, in this union the *alæ* anchylosed and without hingement of any kind. Clefts

extend anteriorly and posteriorly from the ends of the area of union, the anterior cleft being the shorter and its sides making the larger re-entrant angle. The surface of the carapace is marked with fine concentric ridges, as in *Spathiocaris* but is without the radiating lines of that genus.

Of this genus I find three species, as follows:

DIPTEROCARIS PENNÆ-DÆDALI.

Area of union of the sides of the test, or *alæ*, extends about $\frac{1}{8}$th the entire length of the carapace and is situated anteriorly. The antennal or cephalic cleft is $\frac{1}{3}$d the length of the carapace, its sides generally straight, somewhat incurving toward the apex, and making an angle of radius and circumference where they meet the margin of the carapace. Posterior cleft a little less than $\frac{1}{2}$ the length of the carapace, margins curving slightly outward to meet the straight and parallel margins of the carapace at an angle of 46°. Dimensions: length, 50^{mm}, width of each *ala* across area of union, 18^{mm}. The surface is marked as in all of these species by low concentric ridges, somewhat crowded near the center, rather coarser in this species than in the others.

In the illustration (fig. 1) the form is given unintentionally somewhat larger than actual size, and one-half of the carapace is restored in its proper position.

In the light-greenish sandstones of the Lower Chemung, taken from a gully in the town of Canadice, Ontario Co., N. Y., six miles S.E. of the village of Hemlock.

DIPTEROCARIS PROCNE.

Area of union of the *alæ* midway between the anterior and posterior extremities, and reaching less than one-third the length of the test. Anterior and posterior clefts of the same length, the margins of the anterior having a somewhat greater inward curve as they pass to the margin of the carapace than those of the posterior.

The anterior angles made by the margins of the cleft, and the periphery are large—120°—but rounded. Posterior angles sharp—45°. Sides straight, anterior curvature abrupt. Dimensions: length, 23^{mm}; width of each *ala*, 9^{mm}.

Fig. 2 shows a carapace which has been flattened between the layers of sandstone, from the same locality as the preceding.

Fig. 3 shows both *alæ* not flattened, but probably at nearly their normal angle. From the sandstones of the Middle Chemung at Haskinsville, Steuben Co., N. Y.

This species differs from *D. pennæ-Dædali* in these particulars:

a. The anterior marginal curvature is more abrupt and shorter.
b. The area of union is larger and medially situated.
c. The cephalic and abdominal clefts are of the same length.
d. The individuals are, as far as observed, much smaller.

These details of difference are all well shown in the figures.

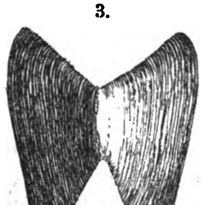
1.

Dipterocaris pennæ-Dædali.

2.

Dipterocaris Procne.

3.

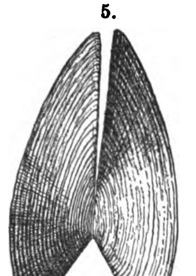


Dipterocaris Procne.

4.

Dipterocaris pes-cervæ.

5.



Dipterocaris pes-cervæ.
(Enlarged 4 diameters.)

DIPTEROCARIS PES-CERVÆ.

Outline of carapace elongate lanceolate, area of union of *alæ* anterior, $\frac{1}{8}$th the length of the test. Cephalic cleft short, margins divaricating at an angle of 68° in the typical specimen and making angles of 78° with the periphery of the test. Posterior cleft long and narrow, the margins making an angle of 6° with each other, and angles of about 23° with the periphery. Dimensions: length 11^{mm}, width of each *ala* $3\frac{1}{2}^{mm}$. From the sandy shales of the Lower Chemung in the cutting of the Delaware, Lackawanna & Western Railroad, at Dansville, Livingston Co., N. Y.

Fig. 4 represents the specimen natural size from which this species is described. Fig. 5, the same, enlarged 4 diameters.

The genera *Spathiocaris* and *Lisgocaris*, which have been described by myself in this Journal as noticed above, show, neither of them, any evidence of a dorsal suture in the carapace. At the time of my description of the genus *Spathiocaris*, the existence of this suture seemed a matter of considerable doubt, as many of the examples in my possession were folded laterally along a median line. More abundant material, however, places beyond a doubt the absence of any hingement, and the fact that the carapace is in one piece. The genus *Lisgocaris* was then proposed to cover a species differing from *Spathiocaris* as then apprehended, in the undoubted absence of this suture, and though rather an aberrant form from the type of the genus *Spathiocaris*, I think it wise, in the light of the additional material obtained, to abolish the name erected for it, and to include it under the genus *Spathiocaris*, the species there described to be *Sp. Lutheri.* With my present conception of these genera, I should not expect to find (though diligent and careful search has been made) any traces of a "rostrum" or free valve to cover the single cleft in *Spathiocaris*, as it does in the genera *Discinocaris* Woodward and *Peltocaris* Salter, which are allied to *Spathiocaris* in some of the grosser features, or to cover the cephalic cleft in *Dipterocaris.* In *Spathiocaris* the cleft seems to be posterior and for the protrusion of the abdomen. In *Dipterocaris* I am inclined to believe, for lack of any evidence to the contrary, that both clefts were uncovered and allowed the protrusion of the cephalic appendages as well as the abdominal somites.

The statement of the absence of the hingement, or the dorsal suture, in Dipterocaris, depends on these observations:

1. There is no mark upon the carapace evincing such a suture.

2. One example of *D. Procne*, having the entire carapace in its normal position, has been subjected to pressure from above by accumulating sediment, in just such a manner as would be most likely to separate the carapace along a dorsal suture if any existed, but instead of such separation the carapace has yielded in concentric wrinkles parallel to its margin.

3. Another example of the same species, flattened in a thin laminated sandstone, has been broken across the area between the apices of the anterior and posterior clefts, and in such a way as to have been left *with a ragged edge.*

Mr. R. P. Whitfield, in this Journal for Jan., 1880 (vol. xix, No. 109, p. 33, "Notice of New Forms of Fossil Crustaceans from the Upper Devonian Rocks of Ohio,") has presented a synopsis of the *Ceratiocaridæ* based upon features of the "cara-

pace alone, independent of the changes which take place in the abdominal segments and in the caudal spines and appendages." Seven sub-divisions of the family are made, the seventh of which includes the forms already mentioned as allied to *Spathiocaris* and *Dipterocaris*, namely, *Peltocaris* Salter, *Discinocaris* Woodward, and also *Aptychopsis* Barrande and *Pterocaris* Barrande, with this characterization. "Carapace composed of three pieces, or apparently of three, two of which are semicircular, with the anterior end of each obliquely truncate, forming, when the two are united, an anterior triangular notch into which the third or rostral plate is inserted; surface concentrically marked by growth lines; no nodes or ridges." None of the sections in this classification cover in as many particulars as this, the genera here and heretofore described by myself, and the description is quoted in full to emphasize the fact that, though the absence of the rostral piece can be regarded as only negative evidence, the unity of the carapace will preclude their admission to same footing as *Peltocaris*, *Aptychopsis* and *Pterocaris*. The genus *Discinocaris* stands apart from these three in the fact of its lack of a dorsal suture, as described (Quart. Jour. Geol. Soc. Lond., vol. xxii), and, with *Spathiocaris* and *Dipterocaris*, may stand as exemplifying a new type of carapace structure provided future investigation leads to the discovery of a rostral piece for the last two genera; otherwise they must remain apart from *Discinocaris* as well as from the other genera mentioned. All of the genera making the somewhat heterogeneous family of the *Ceratiocaridæ*, with the addition of their modern representative *Nebalia*, have been elevated by Packard to the value of an order with the name Phyllocarida.

I take this opportunity of acknowledging my obligation to Mr. C. E. Beecher, of the Geological Survey of New York, for kindness shown me in the confidence of his unpublished observations on new forms of the *Ceratiocaridæ* from the Pennsylvania Devonian, and in the loan of his beautiful drawings for comparative study.

Smith College, Northampton, Mass.

ART. XIII.—*On a Method of Photographing the Solar Corona without an Eclipse;** by WILLIAM HUGGINS, D.C.L., LL.D., F.R.S.

PROBLEMS of the highest interest in the physics of our sun are connected, doubtless, with the varying forms which the coronal light is known to assume, but these would seem to admit of solution only on the condition of its being possible to study the corona continuously, and so to be able to confront its changes with the other variable phenomena which the sun presents. "Unless some means be found," says Professor C. A. Young, "for bringing out the structures round the sun which are hidden by the glare of our atmosphere, the progress of our knowledge must be very slow, for the corona is visible only about eight days in a century, in the aggregate, and then only over narrow stripes on the earth's surface, and but from one to five minutes at a time by any one observer."†

The spectroscopic method of viewing the solar prominences fails, because a large part of the coronal light gives a continuous spectrum. The successful photograph of the spectrum of the corona taken in Egypt, with an instrument provided with a slit, under the superintendence of Professor Schuster during the solar eclipse of May 17, 1882, shows that the coronal light as a whole, that is the part which gives a continuous spectrum, as well as the other part of the light which may possibly be resolved into bright lines, is very strong in the region of the spectrum extending from about G to H. It appeared to me, therefore, very probable that by making exclusive use of this portion of the spectrum it might be possible under certain conditions, about to be described, to photograph the corona without an eclipse.

In the years 1866–68 I tried screens of colored glasses and other absorptive media, by which I was able to isolate certain portions of the spectrum, with the hope of seeing directly, without the use of the prism, the solar prominences.‡ I was unsuccessful, for the reason that I was not able by any glasses or other media to isolate so very restricted a portion of the spectrum as is represented by a bright line. This cause of unsuitableness of this method for the prominences which give bright lines only, recommends it as very promising for the corona. If by screens of colored glass or other absorptive media the region of the spectrum between G and H could be isolated, then the coronal light which is here very strong would have to contend only with a similar range of refrangibility of the light scat-

* Nature, Dec. 29. Communicated in proof for this Journal, by the author.

† "The Sun," p. 239.

‡ "Monthly Notices," vol. xxviii, p. 88, and vol. xxix, p. 4.

tered from the terrestrial atmosphere. It appeared to me by no means improbable that under these conditions the corona would be able so far to hold its own against the atmospheric glare, that the parts of the sky immediately about the sun where the corona was present would be in some degree brighter than the adjoining parts where the atmospheric light alone was present. It was obvious, however, that in our climate and low down on the earth's surface, even with the aid of suitable screens, the addition of the coronal light behind would be able to increase, but in a very small degree, the illumination of the sky at those places where it was present. There was also a serious drawback from the circumstance that although this region of the spectrum falls just within the range of vision, the sensitiveness of the eye for very small differences of illumination in this region near its limit of power is much less than in more favorable parts of the spectrum, at least such is the case with my own eyes. There was also another consideration of importance, the corona is an object of very complex form, and full of details depending on small differences of illumination, so that even if it could be glimpsed by the eye, it could scarcely be expected that observations of a sufficiently precise character could be made to permit of the detection of the more ordinary changes which are doubtlessly taking place in it.

These considerations induced me not to attempt eye-observations, but from the first to use photography, which possesses extreme sensitiveness in the discrimination of minute differences of illumination, and also the enormous advantage of furnishing a permanent record from *an instantaneous exposure* of the most complex forms. I have satisfied myself by some laboratory experiments that under suitable conditions of exposure and development a photographic plate can be made to record minute differences of illumination existing in different parts of a bright object, such as a sheet of drawing paper, which are so subtle as to be at the very limit of the power of recognition of a trained eye, and even, as it appeared to me, of those which surpass that limit.

My first attempts at photographing the corona were made with photographic lenses, but uncertainty as to the state of correction of their chromatic aberration for this part of the spectrum, as well as some other probable sources of error which I wished to avoid, led me to make use of a reflecting telescope of the Newtonian form. The telescope is by Short, with speculum of 6 inches diameter, and about 3½ feet focal length. A small photographic camera was fastened on the side of the telescope tube, and the image of the sun after reflection by the small plane speculum was brought to focus on the ground glass. The absorptive media were placed immediately in front of the sen-

sitive film, as in that position they would produce the least optical disturbance. Before the end of the telescope was fixed a shutter of adjustable rapidity which reduced the aperture to 2 inches. This was connected with the telescope tube by a short tube of black velvet for the purpose of preventing vibrations from the moving shutter reaching the telescope. On account of the shortness of the exposure it was not necessary to give motion to the telescope.

It was now necessary to find an absorptive medium which would limit the light received by the plate to the portion of the spectrum from about G to H. There is a violet (pot) glass made, which practically does this. I had a number of pieces of this glass ground and polished on the surfaces. Three or four of these could be used together, castor-oil being placed between the pieces to diminish the reflection of light at the surfaces. Some inconvenience was found from small imperfections within the glass, and it would be desirable in any future experiments to have a larger supply of this glass, from which more perfect pieces might be selected.

In my later experiments I used a strong and newly made solution of potassic permanganate, in a glass cell with carefully polished sides. This may be considered as restricting the light to the desired range of wave-length, since light transmitted by this substance in the less refrangible parts of the spectrum does not affect the photographic plates.

Different times of exposure were given, from so short an exposure that the sun itself was rightly exposed, to much more prolonged exposures, in which not only the sun itself was photographically reversed, but also the part of the plates extending for a little distance from the sun's limb.

Gelatine plates were used, which were backed with a solution of asphaltum in benzole.

After some trials I satisfied myself that an appearance peculiarly coronal in its outline and character was to be seen in all the plates. I was, however, very desirous of trying some modifications of the method described with the hope of obtaining a photographic image of the corona of greater distinctness, in consequence of being in more marked contrast with the atmospheric illumination.

Our climate is very unpropitious for such observations, as very few intervals, even of short duration, occur in which the atmospheric glare immediately about the sun is not very great. Under these circumstances I think it is advisable to describe the results I have obtained without further delay.

The investigation was commenced at the end of May, 1882, and the photographs were obtained between June and September 28th.

The plates which were successful are twenty in number. In all these the coronal form appears to be present. This appearance does not consist simply of increased photographic action immediately about the sun, but of distinct coronal forms and rays admitting in the best plates of measurement and drawing from them. This agreement in plates taken on different days with different absorptive media interposed, and with the sun in different parts of the field, together with other necessary precautions observed, makes it evident that we have not to do with any instrumental effect.

The plates taken with very short exposures show the inner corona only, but its outline can be distinctly traced when the plates are examined under suitable illumination. When the exposure was increased, the inner corona is lost in the outer corona, which shows distinctly curved rays and rifts peculiar to it.

In the plates which were exposed for a longer time, not only the sun but the corona also is photographically reversed, and in these plates, having the appearance of a positive, the white reversed portion of the corona is more readily distinguished and followed in its irregularly sinuous outline than is the case in those plates where the sun only is reversed, and the corona appears, as in a negative, dark.

Professor Stokes was kind enough to allow me to send the originals to Cambridge for his examination, and I have his permission to give the following words from a letter I received from him: "The appearance is certainly very corona-like, and I am disposed to think it probable that it is really due to the corona." Professor Stokes' opinion was formed from the appearance on the plates alone, without any knowledge of their orientation, and without the means of comparing them with the eclipse plates taken on May 17.

I have since been allowed, through the kindness of Captain Abney, to compare my plates with those taken of the corona in Egypt during the eclipse of May last. Though the corona is undergoing doubtless continual changes, there is reason to believe that the main features would not have suffered much alteration between May 17th and September 28th, when the last of my plates was taken. This comparison seems to leave no doubt that the object photographed on my plate is the corona. The more prominent features of the outer corona correspond in form and general orientation, and the inner corona, which is more uniform in height and definite in outline, is also very similar in my plates to its appearance in those taken during the eclipse.

Measures of the average height of the outer and of the inner corona in relation to the diameter of the sun's image are

the same in the eclipse plates as they are in my plates taken here.

There remains little doubt that by the method described in this paper, under better conditions of climate, and especially at considerable elevations, the corona may be successfully photographed from day to day with a definiteness which would allow of the study of the changes which are doubtlessly always going on in it. By an adjustment of the times of exposure, the inner or the outer corona could be obtained as might be desired. It may be that by a somewhat greater restriction of the range of refrangibility of the light which is allowed to reach the plate, a still better result may be obtained.

Plates might be prepared sensitive to a limited range of light, but the rapid falling off of the coronal light about H would make it undesirable to endeavor to do without an absorptive screen. Lenses properly corrected might be employed, but my experience shows that excessive caution would have to be taken in respect of absolute cleanness of the surfaces and of some other points. There might be some advantage in intercepting the direct light of the sun itself by placing an opaque disk of the sun's image upon the front surface of the absorptive screen. I regret that the very few occasions on which it has been possible to observe the sun has put it out of my power to make further experiments in these and some other obvious directions.

[I have Captain Abney's permission to add the following letter this day received from him. "A careful examination of your series of sun-photographs, taken with absorbing media, convinces me that your claim to having secured photographs of the corona with an uneclipsed sun, is fully established. A comparison of your photographs with those obtained during the eclipse which took place in May last, shows not only that the general features are the same, but also that details, such as rifts and streamers, have the same position and form. If in your case the coronal appearances be due to instrumental causes, I take it that the eclipse photographs are equally untrustworthy, and that my lens and your reflector have the same optical defects. I think that evidence by means of photography of the existence of a corona at all is as clearly shown in the one case as in the other." —*Dec.* 15, 1882.]

ART. XIV.—*An Account of Observations of the Transit of Venus, 1882, made at the Lick Observatory, Mount Hamilton, California;* by DAVID P. TODD, M.A., Professor in Amherst College. (Communicated by the Trustees of the James Lick Trust.)

IN a letter from Captain R. S. Floyd, President of the Trustees, received at Amherst the 7th November last. I was invited to direct the observations of the transit of Venus at the Lick Observatory. I went to Washington as soon as possible, accompanied by Mr. J. L. Lovell, of Amherst, whom I had selected to have charge of the photographic operations in connection with observing the transit. While there, Mr. Lovell received from Professor Harkness and Mr. Rogers such instructions in regard to the special photographic manipulations as our limited time would permit. We left Washington on the morning of the 14th November, arriving in San Francisco at noon the sixth day after. Here we were met by Mr. Thomas E. Fraser, the Superintendent of Construction of the Observatory. A few hours sufficed for the purchase of such portions of the astronomical, photographic and mechanical outfit as had not already been provided; and we were enabled to arrive on the summit of the mountain early in the evening of the 21st. Two weeks then remained before the day of the transit, for completing the unfinished portions of the photoheliograph, mounting and adjusting the same, and making all the photographic and other preparations. Very little time ran to waste, and through the consecutive and uniformly harmonious exertion of every one on the mountain—no one failing in the least of that enthusiastic appreciation which alone could have insured the early attainment of our end—all the apparatus was readily brought into its final condition of certain, convenient and effective working.

Meteorological.—It was our good fortune that the conditions of weather during these two weeks were, in general, very favorable for this preparatory work. No snow fell, and on only two days had we any rains—these very slight. Violent winds interfered with our operations on three or four days. The temperature was rarely below 50°, and most of the time above 60°.

At midnight, the 30th November, the sky cleared, after three and a half days of continuously cloudy weather. From that time until the afternoon of December 7th, we saw no cloud, day nor night, which could interfere in the least with any observation we had to make. Thin cirrus was floating above the summit on the morning of the 2d, but it had van-

ished completely within two hours; and on three or four occasions clouds were observed very near the horizon, but they never rose. The wind blew in fitful gusts night and day the 3d and 4th, and the morning of the 5th. But very soon after 12 o'clock, that day, the winds entirely subsided, and for the next fifty or sixty hours the utmost tranquility prevailed, the temperature never falling below 60°, and rising to very near 70° in the shade at noon on the day of the transit.

Optical.—The sun rose about 7 o'clock, December 6th, with Venus a good way on its disk. The planet was observed by Captain Floyd at intervals throughout the time of transit, with the twelve-inch equatoreal of the Observatory; and with this instrument he made several drawings, and observed the two contacts at egress. The photographic operations were suspended just before the two contacts; and I observed these with the four-inch transit instrument, mounted on its reversing carriage.

Photographic.—The horizontal photoheliograph, with which the pictures of the transit of Venus were taken was constructed by Alvan Clark & Sons, and is, in all essential parts, entirely similar to those made by the same makers for the American Transit-of-Venus Commission. The general theory of this instrument was first published by Professor Harkness in volume xliii of the Memoirs of the Royal Astronomical Society; and subsequently by Professor Newcomb in the "American Observations of the Transit of Venus," 1874, Part I, where a detailed description of the instrument, with plates, is also given.

The Lick photoheliograph, like all the others, has an objective five inches in diameter. Its focal length is almost exactly 40 feet—that is, about $\frac{1}{80}$th part greater than the mean focal length of the eight instruments of the Commission. The diameter of the mirror is a little greater than seven inches; and, unlike the instruments of the Commission, the mechanism supporting the mirror is compactly connected with the clock-work which drives it—all being mounted on a single pier. The objective was mounted on an adjacent pier, and the plate-holder on a third pier coming up in the interior of the photographic house. These piers were all set in the meridian of the transit instrument, and were laid up of brick, their foundation being in the rock of the mountain summit, and their size sufficiently large to insure their absolute stability in every part. The first pictures with the Lick photoheliograph were made with dry plates by Captain Floyd, November 19th, two days before I arrived on the mountain. These confidently assured me that the instrument, although not then in adjustment, and in some parts lacking, was capable of work of the best sort. A suitable exposing-slide had not been provided by the makers; this, however, arrived within two or three days, and

was immediately put in place. The jaw-micrometer and the measuring-rod were received on the mountain in due time before the transit. Three piers were built at once between the transit house and the heliostat, for supporting the tripod of the engineer's level to be used in finding the level-error of the photographic telescope. The tube of this telescope, about thirty-eight feet long and without diaphragms, was cut near the middle, and the half near the objective removed. A tube was then made, about nineteen feet long, of thin plates of iron, diaphragms of sheet lead being inserted as the several sections were riveted together. This tube was a half inch less in diameter than the original tube, and was slipped inside of the remaining half of it—thus giving an air-space between the two tubes, in addition to that between the wooden awning and the exterior tube.

A hood fifteen inches square was made of card-board to cover the plate-holder and the upper part of the pier on which it rested. This was blackened inside, and hinged to the wall of the photographic house, so that it could be pushed up and out of the way when the plates were being put into the holder or taken out. The hood was always pulled down before making the exposure, and thus the momentary flash of light through the photographic house on drawing the exposing-slide, was entirely obviated.

Great care was taken to prevent the mishap of fogged plates from any light falling upon the sensitive film other than that of the sun from the first face of the heliostat mirror. After the adjustments of the heliostat and objective were complete, the following test was applied:—a section of thin iron pipe two feet long and five inches in diameter was fitted with a stopper at one end, and painted jet black outside and in. The sun's image was adjusted centrally on the reticle-plate, the clock-work maintaining it there. The pipe was next set up at various points between the objective and plate-holder, the stopped end being toward the photographic house. Then the pipe being so adjusted that its axis was coincident with the axis of the photographic telescope, the eye of an observer located south of the plate-holder, and looking north through the tube, would readily detect the presence of any object which appeared sufficiently luminous to affect the sensitive plate.

The first photographs of the sun by the wet process—which was adopted in making all our pictures of the transit—were taken November 27th; and we soon after began the accumulation of ample data for the precise determination of the photographic focus of the objective. Sets of photographs, ranging from five to twelve, were taken on six different days, the posi-

tion of the plate-holder being duly changed and recorded between the several photographs of each set. Before the plate-holder was secured in its final position, each photographer had critically inspected all these plates; and without conferring with any one else had made a memorandum of the numbers of those plates in each set which he regarded as indicating the best focus. In addition to this, nearly all the trial-plates were examined independently by Captain Floyd and Mr. Fraser, and all of them on two separate occasions by myself. Nearly all the different determinations were, when collated, in surprising agreement; and the adopted setting of the plate-holder could not have been in error by so much as the $\frac{1}{4000}$th part of the focal length of the objective. In point of fact, the position of the focal plane was definitely indicated to the $\frac{1}{8000}$th part. The superior definition of the photographs of the transit was an entire compensation for all this trouble.

The first photograph of the transit of Venus was taken at $19^{h}\ 11^{m}$, local mean time. The exposure was $1\frac{1}{2}^{s}$ long, and the slit $3^{in}\!\cdot\!0$ wide. Only a very faint image came out on the plate. The fourth exposure, somewhat shorter, and with the slit the same width, at $19^{h}\ 17^{m}$, gave a picture sufficiently intense for measurement; but the vertical diameter of the sun was something like $\frac{1}{4}^{in}$ shorter than the horizontal one, and the limb was not well defined. Plate No. 13, at $19^{h}\ 50^{m}$, slit $1^{in}\!\cdot\!0$ in width, and exposure $0^{s}\!\cdot\!4$ long, is the first photograph of real value, though the five immediately preceding it may be worth measuring. The width of the slit was gradually reduced as the altitude of the sun became greater, being successively $0^{in}\!\cdot\!75$, $0^{in}\!\cdot\!5$ and $\frac{3}{8}^{in}$, until at $21^{h}\ 20^{m}$, it was set at a width of $0^{in}\!\cdot\!25$, and was so kept until the end. The exposures were quite uniformly $0^{s}\!\cdot\!25$ in length.

Three records of the times of exposures were kept—one automatically on the chronograph, the circuit being broken at the precise instant when the middle of the slit passed the central vertical line of the reticle-plate; a second record, by myself, taken from the mean time chronometer in the dark room, and set down at once in the photographic record; and a third record, kept in the transit house by Mrs. Floyd, assisted by Mrs. Fraser, the approximate time of the exposure-click of the chronograph-armature being taken from the face of the sidereal chronometer. As neither the observation of the mean-time chronometer time of the exposure, nor the automatically recorded sidereal-chronometer time, could properly be regarded as complete without the corresponding number of the photograph, this latter was, in every instance, made equally a matter of observation with the time itself; and no plate was ever exposed until I had myself seen and recorded the number it

bore. The chronograph was attended by Professor Welcker, late of the University of California, who made also the observations with the thermometer and barometer.

Thirteen reversals of the plumb-line were made during the period of the exposures. The exposing-slide was moved to the east and to the west, alternately with each exposure, this order never being varied for any reason whatever. I invariably moved the slide, and made all the necessary entries pertaining to each picture in the photographic record myself. The temperature of the photographic house, in which there was no fire, was frequently read from a standard thermometer, the range being from 65°·7 at $19^h\ 51^m$, to 75°·4 at $23^h\ 38^m$. This latter was the time of the last exposure preceding interior contact at egress. After I had observed this contact optically, ten additional exposures were made.

Of the *Photographic Record* proper there are three copies; the original was deposited in the vault of the Observatory, the duplicate is now in my possession at Amherst, and the triplicate was left in the safe of the Lick Trust Office, San Francisco.

The total number of plates exposed was 147. Subtracting from this number all those exposed at the beginning of the day, the ten made between the two contacts at egress, a few worthless ones, and all others of doubtful value, the total number of plates which are available for micrometric measurement cannot fall far short of 125, and may somewhat exceed that number.

Before the plates were finally packed in the boxes I made a comparative estimate, based on a somewhat rapid examination, of the value of these photographs of the transit. Each plate was taken up in order, and a mark assigned to it, on the scale A, A−, B+, B, B−. The mark A means that the plate was judged to be of the very first quality, and capable of the most accurate measurement. Those marked A− are a shade inferior. Second grade plates are designated by B, those a shade better, but not so good as A−, being marked B+; while those not quite up to the grade B are marked B−. A few were judged to be worth only a still lower mark, C. The result was as follows:

A	71	B	9	
A−	23	B−	3	Total, 123
B+	13	C	4	

Mr. Lovell was ably assisted in the photographic work by Mr. Milton Loryea, of San José, whose services were very kindly rendered to the Observatory without compensation, and by Mr. A. P. Flaglor and Mr. O. V. Lange, who were engaged from San Francisco.

Storing of the Photographic Plates, etc.—After the quality of the photographs had been noted in detail, they were carefully packed in boxes of the ordinary pattern, and these latter stored in the upper part of the vault forming the interior of the brick pier, which supports the twelve-inch equatoreal. Tests for absence of moisture were applied to this vault, and as it has the means of pretty thorough ventilation, it is difficult to see how the photographs could be in a more secure place.

Four of the photographs were brought by Captain Floyd to San Francisco and placed in the vaults of the Safe Deposit Company of that city. Within a few days I have sent him the numbers of twenty-four additional plates which he intends bringing down at an early day for safe keeping in the same place. These twenty-eight plates are so selected that in the event of destruction of all those remaining on the mountain, they will of themselves give a very satisfactory record of the transit as seen from Mount Hamilton.

Before I left the summit for San Francisco, there were also stored in the Observatory vault the following parts of the photoheliograph, the constants of which have yet to be investigated:

I. The measuring-rod (in five sections).
II. The jaw-micrometer.
III. The Chesterman steel tape (50 feet).
IV. The heliostat mirror.
V. The photographic objective.
VI. The reticle-plate.

All these were so marked that no doubt can ever arise in regard to the station at which they were used. In addition to the five-section rod used in determining the focal length of the photographic objective, there is on the mountain another rod, of similar pipe-material, which has been carefully compared with the principal rod. This additional rod was left in position over the tube of the photographic telescope. It is made up of three lengths of pipe, put together in the ordinary plumber-fashion, the joints being so marked that the lengths may be brought up always to the same relative position to each other. In the possible event of loss or destruction of the five-section rod, this additional rod will at any time give the focal length of the photographic telescope with nearly equal accuracy.

In conclusion, it is proper that I should remark the full generosity with which the entire outfit for our work on the mountain was provided by the Trustees, and which, while it was in no sense lavish, contributed very largely to the success so gratifying to us all.

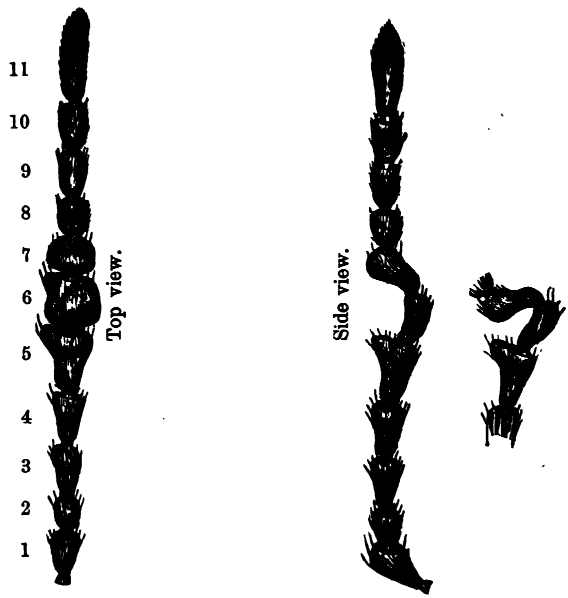
Lawrence Observatory, Amherst, Mass.,
January 16, 1883.

ART. XV.—*On the Antenna of Melöe;* by FRANKLIN C. HILL.

THE antenna of Melöe, male, is so peculiar in form that it has been described by every coleopterist who has seen it, and apparently by some who have not.

This peculiarity consists in a geniculation or hinge involving the fifth, sixth and seventh joints.

The descriptions of this hinge given by European writers vary greatly, even to the extent of locating it in different joints and different numbers of joints, in the same species, *M. proscarabæus* being the one most commonly described, and their drawings are equally varied, very few giving any true idea of the structure.



Melöe angusticollis ♂.
Right antenna × 8.

The American drawings of *M. angusticollis* which I have met with only differ from each other in badness, and the descriptions are worse than the cuts. In Harris's "Injurious Insects" the hinge is located rightly though badly drawn, and in Packard's "Guide" it is worse drawn and wrongly located, while Le Baron in his "Fourth Report," in making a copy of Packard's cut, preserves the errors in the antennæ, and adds a variety of others in the tarsi and abdomen. Both European

and American authors apply a number of terms to the antennæ, as "twisted and knotted," "remarkably swollen and knotted," "writhed or distorted," etc., which do not at all describe it, and no one with whom I have met takes any notice of the remarkable flexure between the sixth and seventh joints which leads me to speak of the geniculation as a "hinge;" and of course they do not hint at a use for the hinge, while one of our best entomologists assured me recently that no use has been found for it.

My drawing shows that it is made up of the fifth, sixth and seventh joints. The fifth is club-shaped, the distal end expanding suddenly inward and downward. The sixth is flattened and nearly square, when seen from above, the outer distal corner being rounded off. Viewed sideways it is slightly arched. The seventh joint is also flattened and when seen sideways has a sigmoid curvature. There is considerable mobility between all the joints involved, but it is greatest between the sixth and seventh, the latter of which folds down until its swollen top almost, if not quite, touches the projecting top of the fifth, making a sort of clasp.

This power of grasping something implies something to be grasped; and after some years of watching, having captured a pair of the beetles last October, I had the pleasure of seeing what that something is, and now can hardly believe that others have not also seen it, though I am unable to find their record. The use is evidently sexual.

In *M. angusticollis*, the male, after placing his mouth against the occiput of the female, kept up a brisk motion there with his trophi, at the same time reaching forward with his antennæ and clasping hers in his hinges, at about the sixth joints.

There seems to be no peculiarity in the antennæ of the female, unless it be that the sixth joints are a little larger than the others, and that there is a slight flexure between the sixth and seventh.

Often, as he closed his hinges, the female drew her antennæ out of them, only to have them seized again at once. When she allowed him to retain them for a moment, he would move backward, drawing her antennæ with his like a bridle. My observations have not succeeded in obtaining further facts; but they are sufficient to convince me that the hinge is "directly connected with reproductive functions," although assured to the contrary on very high authority.

Princeton, New Jersey, December 5, 1882.

ART. XVI.—*Communications from the U. S. Geological Survey: Rocky Mountain Division.*

III. *On Hypersthene-andesite;** by WHITMAN CROSS.

IN the course of the investigation of some apparently normal augite-andesites, of the most typical variety, occurring at the Buffalo Peaks in South Park, Colorado, the writer found that a large part of the pyroxenic constituent possessed the crystalline form and chemical constitution of *hypersthene* rather than of augite. The comparative study of similar andesites from this country and from well-known European localities has forced him to the conclusion that in very many, if not in all of them, augite is decidedly subordinate to a rhombic pyroxene, which is presumably hypersthene. As this conclusion, if proven to be correct, affects materially the current classification of andesitic rocks, the grounds upon which it is based will be concisely stated.

Hypersthene-andesite from Buffalo Peaks, Colorado.

The rock in question occurs in mass, associated with a number of other andesites, prominent among which is a normal hornblende-andesite, and too in fragments imbedded in an important series of volcanic tufas, also of andesitic character. For further information concerning these rocks, the reader must be referred to the forthcoming "Report upon the Geology and Mining Industry of Leadville, Colorado," by S. F. Emmons.

The rock with which we are now occupied is very compact, almost black in color, showing macroscopically a large number of small glassy feldspars, and a few dark, green grains. The ground-mass in which these crystals lie has a dull vitreous luster. When examined under the microscope in ordinary light the rock seems to be an augite-andesite of very typical composition and structure. Clear plagioclase crystals and pyroxene in small crystals and irregular grains, with magnetite and apatite, are the only mineral constituents to be recognized. These larger individuals lie in a ground-mass composed of delicate staves of plagioclase, light green microlites of pyroxene and minute octahedra of magnetite, with a glass base between them, which is usually clear, though sometimes devitrified by light brownish globulites.

* This article is an abstract of a paper to be published as a Bulletin by the U. S. Geological Survey. Its publication has already been delayed for several months, and as a further delay in the Public Printing Office is anticipated, it is deemed best to present the chief results in this form.

The description so far would answer for almost any representative of that sub-group of the andesites usually spoken of as "original" or "normal augite-andesite," or as "Augit-andesit im engeren Sinne," and which is found with unvarying characteristics in Hungary, Transylvania, the Andes of South America, in many islands of the South Pacific, and in the Western United States.

When, however, the pyroxene crystals and grains of the Buffalo Peaks rock are examined in polarized light, it is clear that a large portion of them do not belong to the monoclinic augite. If, in the first place, all those individuals of which the vertical axis seems to lie in, or nearly in, the plane of the thin section, be examined, it is seen that much more than half of them are very distinctly dichroic, and that all of these extinguish light parallel to the vertical axis. The others are not visibly dichroic, and extinction takes place at a very decided angle, usually approaching 40° from the vertical axis.

If, on the other hand, those crystals which are apparently cut at right angles to the principal axis (judging from cleavage and outline) are tested, more than half of them are found to extinguish light when the diagonals of the prism, as indicated by the best developed cleavage planes, coincide with the principal sections of the crossed Nicols. In the remainder there is a very pronounced variation from this action, and one which is not reconcilable with a normal monoclinic or rhombic pyroxene. The limited space of this article prevents an extended discussion of this latter point, which will, however, be fully treated in the bulletin mentioned in the introductory note. It will here suffice to say that from the observations made upon a large number of pyroxene rocks, it seems probable that a triclinic species exists with a crystalline form closely imitating that of the monoclinic system and of a composition identical with common augite.

To return to those dichroic longitudinal sections which extinguish light parallel to the vertical axis: they are pale green in color when that axis is perpendicular to the principal section of one Nicol and greenish-yellow to yellowish-brown when it lies in the Nicol section. The changes cannot be exactly described where the position of the lateral axes is undeterminable. In cross sections neither mineral exhibits marked dichroism. The pleochroism observed in this case does not seem to differ from that often described for the "augite" of the andesites. It is also true that a section of augite parallel to the orthopinacoid cannot be distinguished optically from rhombic pyroxene, as both give extinction parallel to the prismatic axis. It is, however, unreasonable to suppose, even for a single thin section of a massive rock, that any large proportion of the augite crystals of which the prismatic development can be seen are by chance

so situated that the ortho-axis falls in the plane of the section. In all of the sections prepared from the various specimens of Buffalo Peaks "augite-andesite," a majority and usually a large majority of the prismatic sections of pyroxene gave extinction parallel to the vertical axis.

Believing that the optical behavior indicated the presence of rhombic pyroxene in this andesite, and bearing in mind the results obtained by Fouqué in his researches on the Santorin lavas, an attempt was made to confirm the microscopical determination by the isolation and analysis of the questionable mineral. The method of procedure adopted was the same which was used by Fouqué.* A specimen of rock was chosen in which according to the microscopical diagnosis the rhombic pyroxene predominated but slightly over the other, which will be called augite for convenience, though much of it differs optically from that mineral, as has been described. After being suitably crushed, the rock-powder was treated with strong hydrofluoric acid until all but the iron-bearing minerals, pyroxene and magnetite, were dissolved. The latter mineral and such crystals of pyroxene as contained inclusions of it were then extracted with a magnet. The microscopical examination of the residue showed more clearly than ever that two distinct minerals were present, the one markedly pleochroic and seemingly rhombic, the other having the appearance of ordinary augite. This mixture was then further treated with HFl until about one-half had been dissolved. The remainder was found to consist almost entirely of the pleochroic mineral with but a very small amount of the augite. This residue was then subjected to a quantitative analysis.

In this manner the apparently rhombic mineral was isolated from two different rocks from Buffalo Peaks, and the operation was repeated for one of them. Both the isolation and the analysis of the mineral were performed by Mr. W. F. Hillebrand, chemist to the Rocky Mountain Division of the Survey.

The results obtained are presented in the following table. Analysis I is of the whole rock; II and III of portions of the mineral isolated at different times from the rock analyzed; IV of the same from another rock; V † the analysis given by Fouqué for the hypersthene of a Santorin lava; VI ‡ hypersthene from Labrador.

* F. Fouqué. "Santorin, et ses éruptions," Paris, 1879, p. 190.
† Santorin et ses éruptions, p. 195.
‡ J. D. Dana. System of Mineralogy, p. 210.

	I.	II.	III.	IV.	V.	VI.
Sp. gr....	2·742			3·307	3·477	
SiO_2....	56·190	51·703	51·157	50·043	50·12	51·36
Al_2O_3 ..	16·117	1·720	2·154	2·906	2·12	0·37
Fe_2O_3 ..	4919	0·304	------	-----	1·60	-----
FeO....	4·433	17·995	18·360	17·812	23·59	21·27
MnO ...	trace	0·363	0·363	0·120	----	1·32
CaO....	6·996	2·873	3·812	6·696	10·49	3·09
MgO ...	4·601	25·091	24·251	21·744	11·05	21·31
K_2O....	2·368	------	------	-----	----	-----
Na_2O...	2·961	------	------	0·274	0·67	-----
H_2O....	1·028	------	------	-----	----	-----
P_2O_5 ...	0·266	------	------	-----	----	-----
Cl.......	0·022	------	------	-----	----	-----
	99·901	100·049	100·097	99·595	99·64	98·72

In analyses III and IV the total amount of iron is given protoxide, the small quantity of available material rendering satisfactory results impossible. An amount corresponding to that given in II is to be considered as sesquioxide. The MnO of III is taken from II, and is undoubtedly very nearly correct, the portions being derived from the same rock. The microscopic investigation of the material giving results II and III showed an almost total absence of any other substance than the hypersthene. Not more than one per cent of the material could possibly be considered as augite. The method of obtaining the material preserves the crystalline form for most individuals, so that on being mounted in balsam the great majority of the grains lie with the vertical axis in the plane of the slide and the extinction can be clearly seen. In the rock which furnished the material for IV the hypersthene is much better formed than the augite, and the powder of hypersthene finally obtained contains many crystals fully as well developed as those figured by Fouqué for one of the Santorin lavas.* In IV is included a small amount of feldspar attached to hypersthene grains, and which could not be dissolved without losing too much of the latter mineral.

The results obtained, in connection with the optical properties of the mineral, fully justify the application of the name *hypersthene* to the pyroxene, which, in all of the Buffalo Peaks rocks of the type under discussion, is by far the predominating bisilicate. The three analyses given are all very near the theoretical requirements for normal hypersthene, being in fact much nearer than that given by Fouqué, though the correctness of his determination has not been questioned.

* "Santorin et ses éruptions." Plate LX, fig. 2.

Results of the comparative study of the so-called "Augite-andesites."

The limited space of this article does not allow a full discussion of the grounds upon which the conclusion reached by the writer is based. They are, however, stated at length in the forthcoming Bulletin.

A careful study of thin-sections of all the "augite"-andesites of the normal type referred to above which are at the command of the writer, some 31 in number, and representing especially the rocks of Hungary and the Western United States, shows that a rhombic pyroxene is more abundant than augite in each and every one of them. This statement rests chiefly upon the numerical ratio found to exist between those prismatic sections of pyroxene, giving extinction parallel to the vertical axis, and those with oblique extinction. In every case examined the number of the former is greater than that of the latter. In some rocks no distinctly monoclinic pyroxene could be found. Such evidence cannot be ignored simply because there is a possible position for a monoclinic prism in which it cannot be distinguished from a rhombic by the test of extinction. The frequency with which such a position is liable to occur in massive rocks may be fairly ascertained by testing the extinction of hornblende in diorite, or of augite in diabase, in the manner above indicated.

It may be thought strange that the true character of the pyroxene, in so many well-known rocks, has so long escaped detection. A single instance will here be cited, however, which will serve to partially explain the fact. The single hypersthene-andesite mentioned by Rosenbusch, in his standard work, "Die mikroskopische Physiographie der massigen Gesteine," p. 480, has been annihilated by Dr. E. Hussak with the following casual remark: "Eine an neuem Materiale unternommene optische Untersuchung des augitischen Gemengtheiles ergab, dass derselbe nicht rhombisch, wie er bisher bezeichnet wurde, sondern monosymmetrisch ist, da in den klinodiagonalen Längsschnitten desselben der eine optische Hauptschnitt der Längsaxe nicht parallel geht, sondern schief zu derselben steht, und die Auslöschungsschiefe zu über 30° gemessen wurde. Das Gestein ist demnach ein echter Augit-andesit." (Neues Jahrbuch, etc., 1880, i, 290.) Hussak had previously examined the original material and pronounced the designation hypersthene-andesite as correct.* Upon finding some augite in another specimen from the same locality, he concludes that it is "echter Augit-andesit." This latter conclusion is often cited, and so far as is known to the writer has not

* Verhandl. d. k. k. geol. Reichsanstalt. 1878, p. 338.

been questioned. This case simply illustrates the fact that most observers have not considered the possibility of two pyroxenes occurring together in the andesites, and the results obtained by Fouqué, who isolated both augite and hypersthene from the Santorin lavas, have been passed over as interesting but unique.

In conclusion, the writer must not be misunderstood as claiming that all so-called "augite-andesites," of the type described in the beginning of this article, are hypersthene rocks. It is a fact, however, that all of that type which are accessible to him seem to be so, and that no hypersthene rock has been found in any other structural variety of the andesites.

Chemical investigations are now in progress upon several well-known rocks of Hungary which are cited by Zirkel and Rosenbusch as types of "Augit-andesit," and the results will be communicated at an early day.

Denver, Colorado, December, 1882.

ART. XVII.—*A New Method for determining the Collimation Constant of a Transit Circle;* by J. M. SCHAEBERLE.

THE collimation constant of a transit instrument is usually determined by one of the four following methods:

1. By observations of stars in reversed positions of the instrument.

2. By reversal on a collimator or very distant terrestrial object.

3. By combining observations made with the spirit level with nadir observations.

4. By Bessel's method, in which two horizontal collimators (placed on opposite sides of the instrument and having their optical axes parallel) are used.

The last two methods are usually employed in cases where, on account of the construction or size of the instrument, it is not advisable to reverse it very often; or, as in case of the Greenwich circle, where the instrument cannot be reversed at all.

As the greatest possible accuracy is sought with instruments of this class, it is especially desirable to vary the processes by means of which the instrumental constants are obtained. The various results derived, besides serving as a check on data otherwise obtained, furnish means for investigating irregular variations in the so-called constants, due to changes in the material of which the instrument is made.

The method which I am about to propose for finding the collimation constant, without reversing or disturbing the in-

strument, is believed to have some advantages over the ones already mentioned.

A light but rigid framework is hung from the pivots of the horizontal axis, the arms being of such a length that the telescope can be turned to the nadir. The whole arrangement being similar to a hanging level with this difference—in place of a level tube is substituted a plane mirror, securely held in such a position that when the telescope is pointed to the mirror the optical axis will be nearly normal to the reflecting surface.

With the aid of an adjusting screw one of the arms can then be lengthened or shortened until the middle transit wire and its reflected image are nearly in coincidence. The horizontal wire is then brought into coincidence with its reflected image by slightly rotating either the telescope or the hanging collimator about the horizontal axis.

Let m_1=the distance of the middle transit wire from its reflected image; positive when the image is on that side of the wire which is toward the clamp. m_2=corresponding distance after the *collimator* has been reversed. c=collimation constant —then

$$c=-\frac{m_1+m_2}{4}$$

The collimation constant is therefore positive (for clamp west) so long as the algebraic sum of the distances m_1 and m_2 is a negative quantity.

If the pivots on which the instrument rotates are not of the same diameter, the expression for c will evidently become

$$c=-\left(\frac{m_1+m_2}{4}\mp p\right)$$

p being the angle included between the axis of rotation and a rectilinear surface-element of the frustum of a cone having for bases those circular sections of the pivots which rest upon the wyes, the upper sign being used when the clamp pivot is the larger.

On account of the length of the arms of the collimator, inconvenience may be experienced in its reversal unless some changes are made in the castings through which the arms of the hanging level must pass before the instrument can be leveled. This seems to be the only objection that is likely to be raised against the practical application of the method to instruments now in activity. The film of silver, if kept properly covered when not in use, will last for years before resilvering will be necessary.

Ann Arbor, Mich., Jan. 8, 1883.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On metallic Thorium.*—Nilson has succeeded in preparing pure metallic thorium and in determining its properties. For this purpose he used potassium-thorium chloride, prepared by dissolving twice precipitated thorium hydrate in hydrochloric acid, adding two molecules sodium chloride for each one of the thorium chloride, and evaporating in a platinum dish. The dry residue was freed from moisture by heating nearly to ignition in a glass tube through which dry HCl gas was passed. A tube of wrought iron was used for the reduction. First a layer of pure dry sodium chloride was introduced, then the double chloride in alternating layers with sodium, pressed firmly down with a piston, and then more sodium chloride. The tube was closed with a screw cap and heated to a moderate red heat in a furnace. The reduction was completed in 15 minutes; and after cooling, the contents of the tube were treated with water, which left the reduced thorium undissolved. It appeared as a shining gray powder which under the microscope was seen to consist of small thin six-sided plates, the larger ones having the luster of nickel or silver, and being in some cases aggregated together. The crystals are brittle and in an agate mortar give a silver streak. Metallic thorium is permanent in the air up to 100° to 120°. Heated higher, it ignites even below redness, giving a brilliant light and forming snow-white oxide. Its attraction for oxygen is so great, that when heated under fused sodium chloride in a Schlösing's furnace for the purpose of melting it into a globule, it was entirely converted into oxide. It is therefore extremely difficult of fusion. It burns when heated in chlorine, bromine and iodine; but sulphur does not attack it at its boiling point. It does not decompose water at any temperature. Dilute H_2SO_4 attacks it, evolving hydrogen; strong H_2SO_4, with heat, evolves SO_2. Nitric acid dilute has a very weak action; strong, hardly any. Hydrogen chloride attacks it vigorously, evolving hydrogen. Alkali hydrates are without action. The specific gravity was found to be 11·0102, 10·9901 and 10·7824 in three samples. The first two specimens were from the bottom of the reduction tube, the third from near the top. This latter on examination was found to contain 19·4 per cent of oxide. Calculating this out, the specific gravity becomes 10·9178.—*Ber. Berl. Chem. Ges.*, xv, 2537, Nov., 1882. G. F. B.

2. *On the atomic weight of Thorium.*—Nilson has determined also the atomic weight of thorium. The raw material employed was Arendal thorite, of which 2 kilos. were at his disposal. The powdered mineral was gelatinized with hydrochloric acid, the silica removed by evaporation to dryness, the concentrated solution of the chlorides treated with hydrogen sulphide, filtered, treated with ammonia and decanted from the olive-green hydrate.

This after washing, was dissolved in HCl, precipitated with oxalic acid, the oxalates washed, dried and ignited, yielding 950 grams of a brownish-yellow earth. This was moistened with water and then treated with sulphuric acid which dissolved it completely. To obtain the sulphate pure the author took advantage of the fact observed by Berzelius, that the anhydrous salt was easily soluble, requiring 20 parts of water, while the hydrated salt required 88 parts; and further that the former must be preserved in ice-cold water, since on raising the temperature to 20°, the hydrated salt was deposited. The solution of the impure sulphate saturated at the freezing point was heated on the water bath to 20°; an abundant heavy snow-white crystalline precipitate of the hydrated sulphate came down, in amount about two-thirds of the total sulphates. On evaporation, the mother liquor yielded a second crop. By several repetitions of this operation, the sulphate was obtained pure. It was again precipitated with ammonia, the hydrate washed and dissolved in HCl, again precipitated and washed, again dissolved in HCl, converted into oxalate and ignited. The snow-white oxide was converted into sulphate and this was allowed to crystallize by the spontaneous evaporation of its solution. Large transparent brilliant crystals were thus obtained which were permanent in the air and had the composition $Th(SO_4)_2 . (H_2O)_9$. For the estimation of the atomic weight a weighed quantity of the pulverized salt was heated to expel its crystal water, again weighed, and then again heated to a full white heat. The sulphuric oxide was entirely expelled leaving pure thorium oxide which was again weighed. From the data thus obtained, the atomic weight was calculated. Assuming the quadrivalence of thorium, the values obtained were: 1st series, 232·40, 232·43, 232·32, 232·50, 232·39, 232·52; mean 232·43; 2d series 232·39, 232·38, 232·34, 232·38, mean 232·37.—*Ber. Berl. Chem. Ges.*, xv, 2519, Nov., 1882. G. F. B.

3. *On ethyl peroxide.*—BERTHELOT has examined the product of the action of ozone on ether. When a strongly ozonized current of dry oxygen is passed through anhydrous ether, the ozone is slowly absorbed and there remains a dense syrupy liquid, miscible with water, which is ethyl peroxide. It becomes viscous at —40°, but does not crystallize. Heated in a glass tube a portion distils; but the experiment was terminated by a violent explosion. Water decomposes it into alcohol and hydrogen peroxide, which may be separated by distillation. The aqueous solution acts like hydrogen peroxide, decomposing permanganate with effervescence of oxygen, converting chromic into perchromic acid. By the former reaction the author determined the active oxygen in the ethyl peroxide to be 11 per cent, and by the latter 10 per cent. The formula obtained is $C_8H_{20}O_3$ or $(C_2H_5)_4O_3$. The author calls attention to this as a ready means of forming H_2O_2.—*Ann. Chim. Phys.*, V, xxvii, 229, Oct., 1882. G. F. B.

4. *On Catechol-orthocarboxylic acid.*—Of the six acids having the formula $C_6H_3(OH)_2 . COOH$ which theory indicates, five have

already been produced. MILLER has now prepared the sixth, which has the carboxyl and the two hydroxyl groups in the positions 1 : 2 : 3 respectively, and which he calls catechol-orthocarboxylic acid. Two different methods were used: in the first, catechol (pyrocatechin) was heated with ammonium carbonate and water in a sealed tube to 130° to 140° for 14–16 hours. In the second, para-iodsalicylic acid was heated with an excess of potassium hydrate. It forms wart-like groups when anhydrous, melts and decomposes at 204°, gives a deep blue coloration with Fe_2Cl_6 which changes to violet-red with Na_2CO_3, is easily soluble in hot water, alcohol and ether, and gives with lead acetate a flocculent precipitate.—*J. Chem. Soc.*, xli, 398, Nov., 1882.

G. F. B.

5. *Conservation of Solar Energy.*—SIEMENS replies to the objections of G. A Hirn, Comptes Rendus, Nov. 6, 1882, and shows from the experiments of previous investigators that the temperature of the photosphere of the sun cannot far exceed that of the greatest electric light we can produce, and cannot be far, therefore, from 2800° C., and that the dissociation urged by Hirn would not take place. In regard to absorption in interstellar space, Siemens cites the experiments of Dr. J. W. Draper and of Professor Langley, and the opinion of many astronomers, that thousands of stars exist in space whose light is frittered away and never reaches the earth.

In regard to the mechanical resistance exerted by the gaseous matter which Siemens supposes to exist in space, Siemens cites the experiments of Mr. William Froude (British Association, 1875) in regard to the movements of solids in fluids. From which it is concluded that a submerged body moving with uniform velocity in a perfect fluid—that is, a fluid free from viscocity, in which no friction is caused by the gliding of its particles over each other or over the surface of bodies—would not meet with resistance of any kind. He applies this experiment to his theory, and strives to meet the objections of M. Hirn.—*Comptes Rendus*, No. 22, Nov. 27, 1882, pp. 1037--1043. J. T.

6. *Conservation of Solar Energy.*—M. G. A. HIRN replies to Siemens, and reiterates his opinion that the minimum temperature of the sun is 20,000° C., and that the dissociation to which he calls attention in his previous paper will occur. He also maintains his conclusions in regard to the density of the fluid filling interstellar space. The fraction $\frac{1}{10^{16}}$ kg. expresses a value of this density which, supposed to exist, would render the existence of planetary atmospheres impossible.—*Comptes Rendus*, No. 24, Dec. 11, 1882, pp. 1195–1198. J. T.

7. *Reduction of the Mercury Unit of Electrical resistance to absolute measure.*—E. DORN, by a modification of Weber's second method, used also by Kohlrausch, has obtained the following value: $1 \text{ S. E.} = 0{,}9482 \; 10^{10} \frac{\text{MM}}{\text{sec}}$, where S. E. denotes the Siemen or

mercury unit.—*Annalen der Physik und Chemie*, No. 13, 1882, pp. 773–816. J. T.

8. *Approximate Photometric Measurements of Sun, Moon, Cloudy Sky, Electric and other artificial lights.*—Sir WILLIAM THOMSON having referred to the experiments of Pouillet, from which that author infers that the energy radiated by the sun is equal in British units to about 86 foot-pounds per second per square foot at the earth's surface, or about one horse power to every 6½ square feet of the earth's surface, proceeds thus in his calculation: Take, however, instead of the sun an ideal radiating surface of a solid globe of 440,000 miles radius. The distance of the earth being 93,000,000 miles, the radius of the sun is equal to, in round numbers, 1-200th of the earth's distance; hence the area at the earth's distance, corresponding to one square foot of the sun's surface, is equal to 40,000 square feet. The radiation on this surface is $40{,}000 \times 86$ or 3,440,000 foot-pounds, which is therefore the amount of radiation from each square foot of the sun's surface. This amounts to 7000 horse power, or 50 horse power to the square inch. The normal current through a Swan lamp giving a twenty-candle light is equal to 1·4 amperes with a potential of 40 to 45 volts. Hence the activity of the electric working in the filament is 61·6 ampere-volts or Watts (a Watt representing the unit of activity of the ampere-volt). To reduce to horse power we must divide by 746, and we then find about one-twelfth of a horse power for the electric activity in a Swan lamp. The filament is 3½ inches long and ·01 of an inch in diameter, of circular section; the area of the surface is thus 1-9th of a square inch, and therefore the activity is at the rate of three-fourths of a horse power per square inch. Hence the activity of the sun's radiation is about sixty-seven times greater than that of a Swan lamp per equal area. At the conference on Electrical Units which met in Paris lately, a suggestion was made to use as a standard for photometric measurements the incandescence of melting platinum, and very interesting results and methods in connection with the proposal were presented to the meeting. Sir W. Thomson prefers for approximate measurements Rumford's photometer to other photometers, and claims that with a reasonable amount of care measurements can be obtained within two or three per cent of accuracy. Arago has compared the luminous intensity of the sun with that of a candle and estimates it as equal to about 15,000 times that of a candle flame. Seidel estimated the luminous intensity of the moon as about equal to that of grayish basalt or sandstone. An experiment made on sunlight on the 8th of December, 1882, at Glasgow, compared with an observation on moonlight made by Thomson at York during the meeting of the British Association in 1881, has led him to conclude that the surface of the moon radiates approximately one-third of the light incident upon it. The observation on moonlight taken at York—about midnight at the time of full moon—showed that the moonlight was equal to the light of a

candle at a distance of 230 centimeters. The luminous intensity of a cloudy sky was found at 10 A. M., one day also at York, to be such that light from it, through an aperture of one square inch area, is equal to about one candle. An experiment on sunlight, Glasgow, Friday, Dec. 8th, 1882, showed at one o'clock that the sunlight was of such brilliancy that the amount of it coming through a pin-hole in a piece of paper of ·09 of a centimeter diameter produced an illumination equal to that of 126 candles. By cutting a piece of paper of such shape and size that it would just eclipse the flame of a candle, and measuring the area of the piece of paper, 2·7 square centimeters was found as the corresponding area of the flame. This is 420 times the area of the pin-hole, and therefore the intensity of the light from the sun's disc was equal to 126×420 or 53,000 times that of a candle flame. This is more than three times the value found by Arago for the intensity of the light from the sun's disc as compared with that from a candle flame.—*Electrical Review*, vol. xi, Dec. 23, 1882, p. 490. J. T.

9. *Dr. Siemen's Address to the Society of Arts.*—This address contains an interesting calculation of the cost of lighting large areas by electricity. The Parish of St. James in London was taken as an illustration. Its population, according to the census of 1881, was 29,865, it contains 3,018 inhabited houses, and its area is 784,000 square yards, or slightly above a quarter of a square mile. To light a comfortable house of moderate dimensions, to the exclusion of other methods of lighting, would require about 100 incandescence lamps of from fifteen to eighteen candle-power each, that being the number of lamps employed by Sir W. Thomson in lighting his house at Glasgow. Eleven horse power would be required to maintain these lights, and at this rate the Parish of St. James would require 33,200 horse power to light it. It has been proved that the lighting of the Savoy Theater requires 1,200 incandescence lamps, which represent the expenditure of 133 horse power; and about one-half that power would have to be set aside for each of the large public buildings in the parish, constituting an aggregate of 2,926 horse power; nor does this general estimate cover street lighting, and to light the six and a half miles of principal streets of the parish with electric light would require per mile thirty-five arc lights of 350 candle-power each, or a total of 227 lights. This taken at the rate of 0·8 horse power per light represents a further requirement of 182 horse power, making a total of 3,108 horse power for purposes independent of house lighting, being equivalent to one horse power per inhabited house, and bringing the total requirements up to 109 lights=twelve horse power per house. Assuming that the bulk of domestic lighting remains to the gas companies, and that the electric light is introduced into private houses only at the rate of twelve incandescence lights per house, the Parish of St. James would have to be provided with electric energy sufficient to work 63,378 lights=7,042 effective horse power; this is equal to about

one-fourth the total lighting power required. Siemens estimates the cost of the plant at £177,000. Electricity can be produced in London at about one shilling per 10,000 ampere-volts or Watts (746 Watts being equal to one horse power) per hour. Extending the St. James Parish calculation to the whole of London, Siemens estimates that to light it to 25 per cent of its total lighting requirement would require an expenditure of capital of £14,000,000, without including lamps and fittings, thus making an average capital expenditure of £100,000 per district. To extend the same system over the towns of Great Britain and Ireland would absorb a capital of £80,000,000. Siemens also estimates that the cost of lighting by incandescence is 21 s. 9½ d. per lamp for a year, while to produce the same luminous effects in a good argand burner costs 29 s. per year. This shows that lighting by incandescence is decidedly cheaper than lighting by gas. On the other hand, gas companies pay large dividends and can sell their gas at much cheaper rates than at present. Arc lighting is far cheaper than lighting by incandescence.—*Electrical Review*, vol. xi, Nov. 25, 1882, pp. 408–411. J. T.

10. *Die magneto-elektrischen und dynamo-elektrischen Maschinen und die sogenannten secundär-Batterien, mit besonderer Rücksicht auf ihre Construction dargestellt* von GUSTAV GLASER-DECEW. 263 pp. 12mo. Vienna, 1882 (A. Hartleben's Verlag).—This volume is the first of a proposed series of ten which are intended to form an electro-technical library. The titles of these volumes, as given in the prospectus, include all the important subjects involved in the practical applications of electricity, such as the transmission of power by electricity, electrical lighting and heating, galvanic batteries, telegraph, telephone, electro-plating and so on. The interest felt in all these subjects at the present time is so deep and wide-spread that a series such as this, if well carried through, cannot but be highly useful. Volume I of this series now published, discusses the various forms of magneto- and dynamo-electrical machines, dividing them however into two groups according as the currents generated are alternating currents, or of constant direction. The various forms of regulators, of secondary batteries, and so on, are also described; a theoretical discussion of the principles involved in the machines is given and then a statement of their various practical applications; a chapter on instruments for measurement is given in the Appendix. The descriptions in the book are clearly given, the illustrations are numerous and good; it presents in convenient form information which many persons are desirous of obtaining.

11. *A Treatise on the Distillation of Coal-Tar and Ammoniacal Liquor and the separation from them of valuable Products*; by GEORGE LUNGE, Ph.D., F.C.S. 8vo, pp. 383, London, 1882. (John Van Voorst).—The same qualities of accuracy, thoroughness and logical system, which distinguished the author's admirable "Treatise on Sulphuric Acid and Alkali," are found in the present work. It is not very long since coal tar was a waste

product, which the gas-manager was puzzled to dispose of. We quite well recall the time when it was taken out to the open sea and the casks containing it were thrown overboard for the want of any better use to be made of it. The researches of Hoffmann and Mansfeld (1845–47) on the light oils of coal tar and the preparation of pure benzene on a large scale, and, soon after, of nitro-benzene (Essence de Mirbane) as a substitute for the essential oil of bitter almonds, led the way to coal tar distilling on a limited scale; but the great impetus which this industry received was from the discovery of the aniline colors—aniline being derived exclusively from coal tar. From that date (1857) technical chemists have devoted much study to the investigation of coal-tar products, and science has been enriched by the discovery of many new hydrocarbons. Dr. Lunge's treatise is a model of what such a work should be. He handles the subject as only an original investigator can and not merely as a compiler. His main purpose is a clear and full explanation of the methods by which the various useful products existing in coal tar are separated. He does not encumber his book with the transformations and deviations of these products, that being the special work of the chemical manufacturer. The work is profusely illustrated by excellent wood-cuts, mostly to scale, of all the newest and best forms of apparatus in use in the business of the distiller of coal-tar products and the treatment of ammoniacal liquors. The best analytical methods for determination of purity and estimation of quantity are set forth with scientific accuracy. For the technical details, with which this treatise abounds, the reader interested in this line of chemical industry must consult the volume itself.

II. Geology and Mineralogy.

1. *Note on Jointed Structure;* by W. J. McGee.—While collecting statistics of quarry industries in Iowa for the Tenth Census, during 1881, the writer made some observations bearing on the nature and origin of jointed structure. The rocks examined are mainly dolomites and pure or argillaceous limestones, and all exhibit more or less perfect jointing. Two classes of joints (differing only in width) are recognized by the quarrymen, viz: "clay seams" and "dry seams." The general type, as shown in fifty or more quarries, consists of two systems of "clay seams" crossing each other at large angles, with two systems of "dry seams" also crossing each other at large angles but approximately bisecting the angles formed by the principal systems. The phases presented are, however, quite variable: either of the two classes, or either system of either class may be absent, or additional and generally less conspicuous systems—sometimes so blending with the predominant classes as to separate the strata into either irregular or tolerably regular polygonal blocks—may be introduced; and the two classes pass imperceptibly into each

other. Moreover, the blocks themselves, in all rapidly deteriorating rocks, tend to break up on exposure (especially to frost) into prismatic fragments bounded by lines coincident or parallel with the jointage systems. There is every evidence that these jointage planes are superficial: In working downward or back from the face of the quarry the "dry seams" diminish in number and die out, and the "clay seams" attenuate and pass imperceptibly into "dry seams" which finally, in the deeper quarries, nearly or wholly disappear.

It was at first supposed that the phenomena could be satisfactorily explained by the contraction theories recently advocated by Kinahan (this Journal, last vol., p. 68), Crosby (Geol. Mag., viii, p. 416), and others; but from the judicial presentation of the whole subject by Gilbert (this Journal, last vol., p. 50) it appears that these theories are alone inadequate. It may therefore be suggested that the vertical compression and consequent lateral expansion of beds beneath areas of deposition may produce incipient slaty cleavage along certain lines perhaps determined by crystalline structure, and that the vertical expansion and consequent lateral contraction of the same beds when lightened by denudation, and subjected to cooling and desiccation, may develop such lines into jointage planes.

2. *The Climatic Changes of later Geological Times;* by J. D. WHITNEY. Part III, 265–394 pp. 4to. Cambridge, 1882. Vol. vii, No. 2, of the Memoirs of the Museum of Comparative Zoology at Harvard College.—In the preceding Part of Professor Whitney's work on "Climatic Changes of later Geological Times," noticed in a recent volume of this Journal,* the author stated his conclusion that a gradual diminution in the intensity of solar radiation had been the principal source of the change in the earth's climate, and that it went forward through the successive geological periods uninterruptedly, to the end of the Tertiary period. In Part III, he reaches the further conclusion that this gradual change was continued through the Glacial era to the present time, and that a warmer ocean for greater precipitation was the chief cause of Glacial conditions.

The author makes a comprehensive survey of the present distribution and limits of glacier regions, and of the facts illustrating their mode of formation, dealing especially with their dependence on the amount of precipitation. He thus considers the facts from South America, Asia, Europe, and the Polar regions, giving under the latter head a detailed account of the Greenland ice. He dwells at length on the oscillations in the extent of glaciers in the Alps and other glacier regions, and discusses the several explanations of these changes which have been offered. He points out, also, that even in Polar regions large areas are for part of the year without snow, and consequently without glaciers.

In the remarks on the climatic condition of the Glacial era, the facts reviewed are stated to sustain the propositions—now

* Vol. xxiii, p. 489; and Part I, in vol. xxi, p. 149.

generally accepted—that precipitation is one chief requisite for the formation of glaciers and for fixing their limits; and that a general glacial era for the whole earth at any one time is an impossibility; and also the following, about which there is general but not universal agreement, that a lower *mean* temperature than the present did not exist in the Glacial era.

The conditions of the Glacial era next come under consideration; and, on the basis of the facts, another proposition is sustained—now pretty generally admitted—that the ice of that era did not make a "polar ice-cap," and that the two large glaciated areas of the globe were that of Scandinavia and the surrounding country, and that of Northeastern America. He observes, with regard to the other areas of ice, that they were not on so grand a scale "as to make it necessary to admit the existence of conditions of climate or topography, or both, considerably different from those now prevailing over the same portions of the earth's surface." And, with reference to this subject, the facts respecting the present and former glaciation of these and other areas are considered at length, namely those relating to the former extension of the glaciers of the Alps, the Caucasus, the Himalayas, the Thian-Schan Mountains, the Altai and other regions. The review shows wide research, and is presented as favoring the conclusion that there was much less ice in those glacial areas than has been supposed to have existed, and not enough to make it appear that glacial conditions, or climates colder than now, were general even over the higher latitudes (north of 40° to 50°) of the Northern hemisphere.

Next, the limits of the two largest areas—those of Scandinavia and Northeastern America are considered, and with the same result in the author's convictions—that those who have investigated and discussed the subject, both European and American, have made the glacial areas very much larger than actually existed. After this review—which in all parts leaves a desire for more decisive facts, and for a fuller statement of some on record that have a different bearing, Professor Whitney announces as "most clearly" established, that "the Glacial epoch was a local phenomenon, during the occurrence of which much the larger part of the land-masses of the globe remained climatologically entirely unaffected;" that "a higher mean temperature was compatible with a greater extension of the glaciers;" that "there must be copious precipitation, which, although locally in the form of snow, can in reality be only the result of a high mean temperature in other regions;" that, in the words of Frankland in 1864, "the sole cause of the glacial epoch was a higher temperature of the ocean than that which obtains at present" (a view which, as Professor Whitney states in a note, Professor Frankland modified in 1877 so as to make simply "a high temperature of the surface of the sea a necessary condition of the Glacial epoch"); that there has been "a progressive diminution of the temperature on the earth's surface during the geological ages, and from the very

earliest time when land began to exist from the conditions of which light on this subject could be procured."

The physical conditions producing the warmer sea are not considered by Professor Whitney, nor those by which a warmer ocean—from whose area would come warm winds as well as excessive precipitation—occasioned the extensive glaciation of which there is abundant record even in California and Colorado as well as in other colder countries. The argument for narrower limits to the glacial regions than have been laid down, which for Northeastern America is made up more of supposed reasons for doubts than of positive facts of personal observation, can be best met by a new reference to the accounts of original investigators, and by the collection of new facts in this direction. The writer will present the results of a study of the "New Haven region" in an early number of this Journal.

The author does "Professor Dana" much more than justice in the remark that "his authority is almost exclusively followed by the younger workers in Geology in this country;" for, in connection with this subject of the Glacial era, the various State geologists, younger or not, have had knowledge and judgment enough to gather extensive ranges of facts from over the country, east and west, and put forth their well-labored conclusions for his and others' acceptance; and they are leading him onward still further to deductions with respect to the "terminal moraine" or southern limits of the ice, extending from Long Island through New Jersey, Pennsylvania and other States, to Minnesota. Professor Whitney points out that the writer has greatly changed his opinions with the progress of the science by quoting, in a note referring to his recent views, the views he held in 1863. The writer is open to further changes of opinion where new facts may require them; and he will have some to present in the forthcoming article.

J. D. D.

3. *Tenth Annual Report of the Geological and Natural History Survey of Minnesota;* for the year 1881. N. H. WINCHELL, State Geologist. 254 pp. 8vo, with three fine maps and several plates. St. Paul, Minn., 1882.—Professor Winchell presents in this Report an important discussion with regard to (1) the *age of the Keweenaw cupriferous red sandstones, shales and conglomerates;* (2) *the light-colored horizontal sandstones of the south shore of Lake Superior in Wisconsin, holding Fucoids and Scolithus; and* (3) *the St. Croix sandstone containing Lingulæ and Trilobites.*

After a comparison of the rocks and their fossils with those of the Potsdam and Calciferous of the Eastern United States, he derives the conclusions: that all three are of Lower Silurian; that the oldest group of the vicinity of western Lake Superior is the Animikie group of Hunt, which includes slates, quartzyte and some dolomite, and which on the northwest shore of Lake Superior, in Thunder Bay, carries ores of silver; and that it is probably Acadian (Menevian) in age; that this formation is

overlaid by the Cupriferous (No. 1, above), and "so far as evidence goes it appears in Minnesota to graduate into this overlying formation conformably;" that the overlying Nos. 2 and 3, which consist of horizontal light-colored siliceous sandstones with some dolomitic layers near the top, and at some points lie unconformably on the tilted copper-bearing rocks (No. 1), and whose many fossils (including among the Trilobites 6 species of *Dicellocephalus*, 8 of *Conocephalites*, 3 each of *Ptychaspis* and *Agnostus* and others), show a relation in age to the Quebec group, though cautiously assigned to the Potsdam period by Hall. Professor Winchell is hence disposed to consider the St. Croix sandstone of the age of the Quebec group. [At present it seems probable that the Quebec group in the east will ultimately become divided between the Calciferous and Chazy.] The red sandstone formation of Keweenaw is stated to be "locally changed to gneiss, syenyte, and hard red quartzytes, as well as interbedded with doleryte and mixed with gabbro."

Professor Winchell also states on page 112, in connection with a description of Minnesota rocks, that about Beaver Bay a red conglomerate occurs changed to red syenyte; and that the altered rock was in a plastic state, as shown by its running in belts and veins through the trap and the associated feldspar rock. "The feldspar masses are geologically from the same rock as the Rice Point gabbro, and both are the result of copious, and perhaps one of the earliest, igneous outflows of the Cupriferous."

The Report also contains descriptions and figures of some fresh-water Entomostracan and other Crustaceans of Minnesota, by C. C. Herrick. Two species of Decapods are mentioned as occurring in the rivers of the State, *Cambarus virilis* Hagen, and the species, here first described and named, *C. signifer.*

Flooded Lake Winnipeg.—In the prefatory "summary statement" of the Report, a notice is given of the present views of Mr. Warren Upham with regard to flooded Lake Winnipeg, to which, as stated on page 433 of the last volume of this Journal, he has given (unfortunately we think) the name Lake Agassiz. Mr. Upham makes the lake to have covered not merely the Red River prairie region of lœss (which bears evidence of lacustrine conditions), as stated by General Warren and others, but to have spread far eastward of this limit over the upper prairie (which is characterized by coarse deposits such as mark fluvial and drift conditions); and to have probably covered Red Lake under 50 or 100 feet of water, Lake of the Woods under about 200 feet, the Red River Valley at St. Vincent 450 feet, and Lake Winnipeg *about* 600 *feet.*" The evidence referred to as supporting this conclusion consists in "beach lines," of which there are three. The evidence that these supposed beach lines were of lacustrine origin and not fluvial is not given in this brief summary.

In explanation of the conditions of water-level it is stated that the beaches "have been ascribed to the operation of the glacial period in the epoch of its decline, when the ice still existed to the

north to prevent northern drainage. The same obstruction [the ice] must have existed in the Red River Valley, and, in the opinion of Mr. Upham, *its attraction was sufficient to move the mass of the water toward itself, and to cause an ascending shore line in that direction.* Any such barrier, operating inversely as the squares of its distance from different parts of the lake, would thus cause a more rapid ascent in those portions of the shore line near it than in those more remote." But the barrier of ice, even if 2,000 feet thick, would have been equivalent in mass to less than an 800-foot layer of rock; and the rise against such an ice-barrier at Lake Winnipeg would have been, if the water extended 300 miles to the southward, not over fifty feet—giving to the shore-line of the great lake a slope very different from what observations show to have been the fact. While such conditions (the surface being still *level*) help nothing the southward flow, they make deeper water near the barrier, and hence would increase the tendency of flow northward beneath the ice. J. D. D.

4. *Geological Survey of Pennsylvania.*—This Report of the Board of Commissioners to the Legislature, dated Jan. 1, 1883, states that the survey of the State, both geological and topographical, is mostly completed, only a few areas remaining, the study of which will occupy the year 1883. The work has gone forward with great energy under the direction of Professor Lesley, and with remarkable promptness in the publication of the Reports on the work of each year, all of which have been carefully prepared, and are essentially final Reports. The chief work remaining is the special underground as well as above-ground survey of the Anthracite region, which has been in progress for eighteen months. As the object of the Anthracite survey is to make an exhibit of the structure, position and thickness of coal-beds and associated rocks, with that completeness of underground detail that will render the maps and sections an aid and guide to the coal-worker of the future as well as present time, the progress of the survey is necessarily slow. Three years more will complete it; and as the anthracite industry "has contributed to the State, directly and indirectly, millions of dollars in taxation," the amount required for three more years is confidently looked for from the Legislature.

5. *Permian Plants of Colorado.*—In the red-beds of South Park, Colorado, near Fairplay, a shale contains, besides remains of insects, scales, seeds and leaves of Conifers, a stem of a Lepidodendron and remains of Ferns. Professor L. Lesquereux, to whom the specimens were sent by Professor Scudder (which were partly of his collection but in part from the Museum of Comparative Zoology), has examined the plants and found that among the species there are the following which are characteristic of the Permian: *Ullmania frumentaria* Göpp., *U. selaginoides* Gein., *U. Bronnii* Göpp., *Walchia piniformis* St., *W. longifolia* Göpp., a species of *Abietites*, *Callipteris conferta* Weiss, *Odontopteris obtusiloba* Naum., *O. cordata* Göpp., *Cyclopteris rari-*

nervis Göpp., *Sphenopteris Geinitzii* Göpp., *Hymenophyllites Leuckarti* Gein., a species of *Schizopteris.*—*Bull. Mus. Comp. Zool.*, Cambridge, Mass., vol. vii, No. 8.

6. *Nummulitic deposits in Florida.*—Specimens of a white or yellowish-white friable limestone, from the vicinity of the Cheeshowiska River, Hernando County, four miles from the coast, consist chiefly, according to Mr. ANGELO HEILPRIN (Proc. Acad. Sci. Philad., 1882, p. 189) of Nummulites of the genus *Nummulina.* They are of one species which he names *N. Willcoxi,* from its discoverer Mr. Joseph Willcox. It is remarkable, as stated by the author, that the accompanying fossil mollusks are of species more recent than Eocene, even *living species of fresh-water genera,* viz: *Glandina parallela, Paludina Waltonii, Ampullaria depressa.* But the genus, *Orbitoides,* which had its largest development in the Upper Eocene, is also present, indicating, with "little or no doubt," that the rock fragments "derived their faunal character from deposits of a more ancient formation," either Eocene or Oligocene; and the original beds may possibly be now submerged.

7. *Lapparent's Traité de Géologie.*—The last part of this very valuable work, extending it to 1280 pages, has just been issued.

8. *Pot-holes in the Bronx Valley, Westchester County, New York.*—In the Transactions of the New York Academy of Sciences, No. 8 of vol. i, May, 1882, Dr. N. L. BRITTON describes large pot-holes in fine-grained gneiss, west of the Bronx, two to three miles north of Williams Bridge. One, about 9 feet deep and 10 feet in diameter at middle, is at bottom 18 feet above the present level of the stream; and another about 10 feet deep is 20 to 22 feet above.

9. *Sulphur deposits at Cove Creek, in Millard County, Southern Utah.*—The publication cited from in the preceding paragraph contains a note by Mr. I. C. RUSSELL on the Sulphur deposits of Cove Creek. At this place fifteen mines have been "located," a few of which have been developed to a slight extent. At one place the sulphur occupies a nearly extinct solfatara; at others it impregnates and cements beds of tufa, or lines fissures with crystals. Two miles south of the fort at Cove Creek the solfatara occupies nearly a circular crater 1200 feet in diameter, and at its center the impure sulphur has a depth exceeding 25 feet. Sulphur depositions are still in progress from escaping vapors.

A mile north of Cove Creek, at the Philadelphia Mine, a fissure in trachyte is lined with sulphur crystals; and at the Mammoth Mine, fissures and openings in dark-colored Carboniferous limestone. A volcanic cone southwest of Cove Creek stands on the Mammoth Mine line of fracture and faulting.

The deposit of gypsum associated with the sulphur is sometimes eight feet thick, and those of alum, two feet. Hot springs occur in the same region.

10. *On some minerals from the sodalite-syenite in the Julianehaab district in South Greenland.*—The sodalite-syenite and as-

sociated minerals occurring on both sides of the Tunugdliarfik and Kangerdluarsuk fiords in southern Greenland have been recently studied by J. LORENZEN of Copenhagen. The chief constituents of the rock are a greenish-white feldspar, arfvedsonite (and ægirite) and sodalite; there also occur eudialyte, nephelite, lepidolite, ænigmatite, and a new mineral called steenstrupine; also at one spot ilvaite with calcite, and finally some zeolites, in particular analcite and natrolite. It is noted as a point of special interest that the association of minerals is very closely the same as that observed in the syenite of Langesundsfjord in southern Norway. The author gives the results of careful analyses of the arfvedsonite, ægirite, sodalite, nephelite, eudialyte, ilvaite and lepidolite. The mineral called steenstrupine is named after Mr. K. J. V. Steenstrup of the Danish Geological Survey of Greenland. It occurs massive, also in indistinct curved crystals, the edges and planes appearing as if gnawed. Rarely the crystals admitted of partial determination; they were concluded to be combinations of the basal plane with one or two + rhombohedrons and perhaps a − rhombohedron; for the angle between the basal plane and the fundamental rhombohedron was obtained 128° approximately. The color is brown, streak nearly white. Hardness =4, specific gravity =3·38. It fuses rather easily before the blowpipe to a gray dull bead. An analysis yielded:

SiO_2	Ta_2O_5	Fe_2O_3	Al_2O_3	ThO_2	MnO	CeO	LaO, DiO	CaO	Na_2O	H_2O
27·95	0·97	9·71	2·41	7·09	4·20	10·66	17·04	3·09	7·98	7·28=98·38

No attempt is made to calculate a formula since more analyses are needed to establish the chemical composition.

11. *A Treatise on the Metallurgy of Iron, etc.;* by A. BAUERMAN, F.G.S. 5th edition, revised and enlarged. 515 pp. London, 1882 (Crosby Lockwood & Co.).—This excellent little book is now so well-known that it needs no extended notice. The fifth edition, recently published, includes considerable additions, discussing especially the Siemens and Bessemer processes for the manufacture of steel; notices of important deposits of iron ores in Spain, northern Africa and elsewhere have also been given.

12. *Materialien zur Mineralogie Russlands*, von N. VON KOKSCHAROW. Vol. viii, pp. 331–432. St. Petersburg, 1882.—Volume viii of Professor Kokscharow's great work on the Mineralogy of Russia is completed by the one hundred pages recently published. The species discussed are: analcite, vauquelinite, aragonite, chiolite, chodneffite, vauquelinite (and laxmannite, the two being shown to be identical), chrysolite, wulfenite, amphibole (nephrite) mica, rhodizite, crocoite, perofskite, pachnolite. Of these species, vauquelinite and wulfenite are treated to extended monographs; the descriptions of the others are supplementary to monographs which have appeared in some earlier part of the work.

13. *Notes from the Laboratory of the University of Virginia.*—Recent numbers of the Chemical News have contained a con-

tinuation of Notes of Work by Students in the Laboratory of the University of Virginia, under the charge of Professor J. W. Mallet. The following analyses are extracted. An analysis of *allanite* from Bedford Co., Va., by W. T. Page, yielded:

SiO_2	Al_2O_3	Ce_2O_3	Di_2O_3	La_2O_3	Fe_2O_3	FeO	BeO	MgO
26·70	6·34	33·76	16·34	1·03	3·21	4·76	0·52	0·54

CaO	Na_2O	K_2O	H_2O	MnO
2·80	0·49	0·55	1·99,	tr.=99·03.

The specimen was black, compact with pitch-like luster; specific gravity 4·32. It is remarkable for the high percentage of the cerium metals, more especially of didymium.

The *helvite* from near Amelia Court House, Va., has been analyzed by B. E. Sloan, with the following results:

SiO_2	BeO	MnO	FeO	Al_2O_3	Mn	S
31·42	10·97	40·56	2·99	0·36	8·59	4·90=99·88

Specific gravity 3·25. The material analyzed was pure, consisting of fragments of tetrahedral crystals; the analysis consequently represents more nearly the composition of the species than the earlier one by R. Haines, (this Journal, xxiv, 155).

Grains of *metallic iron* accompanying native gold in Montgomery Co., Va., have been investigated by W. T. Page. They occur in the alluvial washings in the bed of Brush Creek; the largest weighed 60 to 80 milligrams, the smallest were almost dust, the average weight being 5 milligrams. Some of the grains were rounded but many are flattened scales, often twisted, with rough ragged edges. Specific gravity 7·20. It is regarded as reasonably certain that these grains are really native iron. An analysis gave:

Fe	Cu	S	Quartz.
97·12	0·04	1·47	0·82=99·45

Similar grains, according to the same observer, occur in the auriferous sands of Burke Co., N. C.

An analysis of colorless *mimetite* in slender hexagonal crystals from the Richmond mine, Eureka, Nevada, afforded F. A. Massie:

As_2O_5	P_2O_5	PbO	$PbCl_2$
23·41	tr.	68·21	8·69=100·31.

Analyses are given of fergusonite from Brindletown, N. C., of altered samarskite ("euxenite") and of allanite (orthite) from Mitchell Co., N. C., all by W. H. Seamon; these analyses have already been quoted in this Journal, but without the name of the analyst.

A mineral from the Great Eastern Mine, Park Co., Colorado, has been analyzed by W. T. Page, which proves to be allied to bournonite and stylotypite, having the same general formula. It had a crystalline structure, a steel-gray color and dark-red streak. Specific gravity 4·89. The analysis gave:—

S	Sb	Cu	Zn	Fe	Pb	gangue.
26·88	34·47	23·20	7·14	1·38	1·19	5·86=100·12

The copper is stated to be present, one-half as cuprous, one-half as cupric sulphide.

Native Palladium Gold, from Taguaril, near Subara, Minas Geraes, Brazil, has been analyzed by W. H. SEAMON, containing 8·2 per cent palladium; specific gravity 15·73, the color was dark or bronze-like.

14. *Analyses of Danburite from Switzerland.*—The occurrence of danburite on the Skopi, Switzerland, has already been noticed. The following analyses, 1 by Schrauf, 2 by Bodewig, (Z. Kryst., vii, 391) show that it corresponds exactly with the American mineral.

		SiO_2	B_2O_3	CaO	Fe_2O_3,	Al_2O_3	ign.
1.		48·92	[26·88]	21·97	1·87		0·36=100·00
2.	(⅔)	48·66	28·09	22·90	0·23	0·08	---=99·96.

15. *Native Lead and Minium in Idaho;* by W. P. BLAKE. (Communicated).—These comparatively rare species are found together in the midst of masses of galenite at the Jay Gould Mine, Alturas County, Idaho Territory, not far from Bellevue. The metallic lead is in small rounded masses or grains from an eighth to one-quarter of an inch in diameter, and sometimes in irregularly reniform bunches, weighing an ounce or more. The red oxide is in the form of coatings or crusts on the metal. Neither are abundant.

16. *Topaz from Stoneham, Maine.*—At the meeting of the New York Academy of Sciences, held Nov. 7th, 1882, Mr. G. F. Kunz announced the discovery by him at Stoneham, Maine, of topaz in fine and large crystals, in habit resembling the Russian. The largest of the more transparent ones measured about three inches in the direction of the macrodiagonal, and two and one-half parallel to the vertical axis. The color is of a bluish and greenish tint. Some of the large opaque masses were parts of crystals measuring one foot across. Associated with these were damourite, triplite, triphylite, columbite; one mass of the latter weighing over seventeen pounds, and the pink mineral (montmorillonite ?) described by Brush and Dana as occurring at Branchville, Conn.

III. BOTANY AND ZOOLOGY.

1. *On the occurrence of Formic and Acetic Acids in Plants, and their physiological importance in Metastasis;* by Dr. E. BERGMANN. (Bot. Zeit., Oct. and Nov., 1882.)—Since the detection of acetic acid in plants by Fourcroy and Vauquelin in 1809, and of formic acid by Döbereiner in 1831, these substances have been found in many species of plants. Availing himself of a modification of the silver method as a test for the latter acid, Dr. Bergmann has examined a large number of plants for the purpose of determining under what conditions the acids are formed and what part they play. His results are briefly summarized as follows:

(1.) Formic and acetic acids occur in protoplasm throughout the

whole vegetable kingdom. They are found in the most widely different parts of plants, and are present both in plants which contain chlorophyll and in those which are devoid of it.

(2.) They are constant products of metastasis in vegetable protoplasm.

(3.) It is probable that other members of the series of volatile fatty acids (propionic, butyric, caproic and perhaps the whole series) have a very wide diffusion throughout the vegetable world.

(4.) There is an increase in the amount of volatile acids in a plant in which assimilation has been arrested by withdrawal of light, and in which the state of inanition has supervened.

(5.) Formic and acetic acids are probably produced by retrograde metamorphosis.

(6.) In a plant subjected to a temperature below that of the minimum of growth, and at the same time deprived of light, there is no increase in the amount of volatile acids.

(7.) The formation of these acids appears therefore to be somehow independent of the respiratory process.

(8.) In all probability they result from the splitting up of constituents of vegetable protoplasm. G. L. G.

2. *Conspectus Floræ Europææ, seu Enumeratio Methodica Plantarum Phanerogamarum Europæ Indigenarum, indicatio distributionis Geographicæ singularum*, etc. Auctore CAROLO FRIDER. NYMAN. Orebro Sueciæ, 1878–1882, pp. 858, 8vo.—We have noticed the three earlier parts of this work, and may now announce its completion. It is the best substitute for that *desideratum*, a Flora of Europe, and, from its compactness, extremely useful even if we had such a Flora. Dr. Nyman hopes to bring out a Supplement, to contain later discoveries, in which he will give the Ferns and their allies, perhaps the *Characeæ* also. He will add, likewise, a full index of species and synonyms, which has been prepared for the present volume, but was omitted for want of room. A. G.

3. *Flora Brasiliensis.*—Dr. EICHLER has made progress with this great work since our last announcement. We now have fasc. 86, in which Dr. Drude completes the *Palmæ;* fasc. 87, containing the Asteroid and Inuloid *Compositæ*, by Mr. Baker of Kew; and the thin fasc. 88, containing the *Halorageæ* by Dr. Kanitz, of Klausenburg. The first and the last of these terminate volumes. A. G.

4. *Flora of British India*, part IX.—This part completes the third volume (*Caprifoliaceæ–Apocynaceæ*), of 708 pages, 1880–1882, and being issued at the close of the latter year, shows good progress. The greater portion of this part (*Vacciniaceæ* to *Salvadoraceæ*) is the work of the indefatigable and acute C. B. CLARKE; the large and difficult order *Apocynaceæ* by the editor, Sir J. D. HOOKER. Among the Gaultheria-like *Ericaceæ* is a *Diplycosia? semi-infera*. The American *Chiogenes*, put in *Vaccineæ* on account of its technical character, though otherwise Gaultheria-like, has its ovary half or two-thirds inferior; all going

to show that the *Vaccinieæ* should rank only as a suborder of *Ericaceæ*. A. G.

5. *Causes determining the Distribution of Oceanic life in depth.*—Prof. T. FUCHS has published an important paper on this subject in the Vienna Geological Verhandlungen, No. 4, for 1882.* He arrives at the conclusion that while *temperature* is a chief cause of the distribution of littoral species, *amount of light* is the prominent limiting cause in depth; and that this cause determines the limit between "that which we distinguish as a littoral fauna and a deep-sea fauna;" in other words, "*that the littoral fauna is nothing but the fauna of light, and the deep-sea fauna the fauna of darkness;*" and that this is true also for the main part in fresh water lakes.

Prof. Fuchs remarks that the limit to which light penetrates downward, according to Secchi, Pourtales and Bouguer, is 43 to 50 fathoms, but saying, in view of the occurrence of nullipores at 180 fathoms, that a feeble amount may penetrate farther; and after a wide survey of facts from the ocean he arrives at this depth as that of the boundary between the two faunas; the *deep-sea* fauna becoming very abundant, the world over, below this limit, and especially at about 90 to 100 fathoms, as shown in the deep-sea corals, echinoderms, and other species;† while much the larger part of the littoral species are confined within 30 fathoms of the surface. The following table presents some of the facts:

	Deep-sea Corals.	Brachiopods.	Authorities.
Norway	60 fathoms.	30 fathoms.	M'Andrew and Barrett.
English Coasts	50		Forbes.
Bay of Biscay	31	31	Fischer.
Mediterranean	50	50	
Florida	40		Pourtales and Agassiz.
Brazil	30–40		Hassler Expedition.
Philippines	40		Semper.
Cruise of the Gazelle	40		Studer.

The passage from one fauna to the other occurs between 30 and 90 fathoms; but at the same time there is in the tropics below the 30-fathom line an extremely sterile region with few animals, that continues to a depth of about 80 or 90 fathoms, which intermediate sterile zone is unknown in the temperate and colder seas. Vitreous sponges occur most abundantly at 90 to 100 fathoms. Those of the Philippines live at depths not below 100 fathoms, and several species occur near Barbadoes, between 80 and 100 fathoms, along with numerous species of deep-sea corals and some crinoids.

* Verhandlungen der k. k. geologischen Reichsanstalt, 1882, No. 4, pp. 55–68; and, translated (by W. S. Dallas), in the Ann. Mag. Nat. Hist., for January. The above abstract is made from the latter.

† The following are enumerated as the most characteristic types of the deep-sea: Of corals, Oculinidæ, Cryptohelia and various solitary species; the Vitreous sponges; Crinoids (Pentacrinus, Rhizocrinus, Hyocrinus, Bathycrinus); of Echinoids, Echinothuriæ, Pourtalesiæ, Ananchytidæ; of Asterioids, Brisinga; Holothuriæ of the sub-order Elasmopodia; Fishes, ribbon-like in form, of the families Lepidopidæ, Trachypteridæ, Macruridæ and Ophidiidæ.

To the common observation that surface arctic species extend along the cold depths of the ocean toward the equator and the antarctic seas, Prof. Fuchs says that these arctic species are few and not characteristic kinds; and that some are not littoral species, but from the deep-sea as elsewhere.

Prof. Fuchs speaks of the abundant life in the arctic seas notwithstanding the coldness of the waters, the temperature ranging between 28° F. and 35° F.; of a temperature suitable for tropical species (70° F.) in the Red Sea down to a depth of 600 fathoms, and yet, as far as known, the littoral species do not extend deeper than in other seas; of vitreous sponges, deep-sea corals, Brachiopods, etc., living, between Norway and Iceland, in waters having a temperature between 30°·2 and 28°·4 F.; of similar kinds, and many of them the same in species, occurring at the same depth off Scotland and Ireland, in waters 43° to 48° F. in temperature; on the Pourtales Plateau, in waters at 44° to 56° F.; and on the Euplectella grounds near the Philippines, in waters at 59° F. (Semper), and off the island of Cebu, in 69°·8 F. (Moseley.) The statement of these and other facts, unfavorable to the idea that temperature is the cause of limitation in depth, he prefaces by the remark that "Dana has already repeatedly and emphatically pointed out that temperature plays only a very subordinate part in the distribution in depth of sea-animals;* and the facts which may be cited in favor of this are of so convincing a nature that one cannot help wondering how such an opinion, as the above, could so long prevail."

Prof. Fuchs observes further that *pelagic* species, or those of the open sea, are really *species of the darkness;* that they come up to the surface as the light fades away into night, and return with approaching day; that, like the deep-sea species, many of them have the deep-sea feature of phosphorescence, fitting them for life in the darkness.

Prof. Fuchs queries also whether some littoral species which extend down to great depths, may not be species that hide themselves during the day in dark places, or shut themselves up in their shells; and whether true deep-sea species may not often occur mixed with the littoral in the cavernous recesses about coral reefs and on other shores; and suggests to the geologist the importance of this consideration, as is also the fact that the dark sea-depths exist at only 50 fathoms. In this connection he states that the blind Isopod of the genus *Cœcidotœa* (*Asellus Borelli* is referred here by Cope and Packard), occurs in the great depths of Lake Geneva, as well as in the American and Carniolian caves; and that while the Ophidiidæ (near allies of the Gadidæ) are the most abundant and characteristic kinds of deep-sea fishes, and several of them are blind, there is the remarkable fact that two blind Ophidiidæ, showing close resemblance to their deep-sea relations, occur in the caves of Cuba.

* This Journal, vol. xv, p. 2[illegible]4, 1853. Also, Exp. Exp. Report on Zoophytes, 1846, p. 103, Report on Geology, 1849, p. 97, and Report on Crustacea, 1852, p. 1485.

With regard to the littoral region, Prof. Fuchs points out that there are three prominent assemblages of species: (1.) the seaweed areas, which do not reach down below 30 fathoms, and are very abundant in species; (2.) the coral-reef areas, not passing the limit of 20 fathoms, which are "the gathering grounds of an extremely rich fauna," and so peculiar that the terms coral-fishes, coral-mollusks, etc., would not be inappropriate; a fauna that embraces "the whole splendor of the animal life" of the Indian and Pacific Oceans; and (3.) the areas of large bivalves such as oysters, pearl oysters, scallops, which have their maximum development in from 8 to 10 fathoms and are not found below 20 fathoms. Each of these groups must have their limit fixed by the amount of light they require.

Prof. Fuchs does not speak of the effects of temperature carried over portions of the sea bottom by great oceanic currents from the north and south, and the division consequently of the deep-sea fauna in those parts into a warmer and colder, characterized by some difference in genera and species, this being outside of his special subject.

IV. Astronomy.

1. *Parallax of Alpha Lyræ and of* 61[1] *Cygni.*—In a memoir which is to form one of the appendices to the Washington Observations, Professor Hall has given in full his observations upon the above two stars made between May, 1880, and December, 1881, with the large refractor. An account of this work was given to the American Association at Montreal. The measurements were in each case those of differences of declination with neighboring small stars. They were uniformly in sets of eight, and were made on 77 and 66 nights respectively.

The resulting parallax is deduced for α Lyræ for each of the two kinds of illumination separately. For dark lines on a bright field sixty-nine sets of observations give a parallax of $0''{\cdot}1556 \pm 0''{\cdot}00764$; for fifty-nine sets with bright lines on a dark field, $0''{\cdot}2080 \pm 0''{\cdot}00827$. The combined result by weights is

$$\pi = 0''{\cdot}1797 \pm 0''{\cdot}005612.$$

This parallax is differential with the small 10th magnitude companion nearly south of Vega. Assuming this star's parallax to be insensible, the time required for light to pass from Vega to our sun is 18·11 Julian years. The differences of declination were a little greater as measured with bright wires than with dark ones.

Only the first kind of illumination was used for 61[1] Cygni. The result from sixty-six sets of observations gives for the parallax as compared with D. M. +38°, No. 4345 (a star of the 9·5 magnitude, about $3'{\cdot}3$ south of the double star)

$$\pi = 0''{\cdot}4783 \pm 0''{\cdot}01381.$$

The corresponding time for light to pass from this star to our sun is 6·803 Julian years. The color correction of the Washington

refractor seems to be better adapted to the color of α Lyræ than to that of 61^2 Cygni, and this may be a reason why the probable error is larger for the latter determination.

There are no stars which have been so frequently and withal so carefully investigated for parallax as Vega and 61^2 Cygni. It may be interesting to place alongside of Professor Hall's elaborate determinations other published values of the parallaxes of the same stars.

α Lyræ.	"	61^2 Cygni.	"
F. Struve	0·261	Arago	0·55
C. A. F. Peters	0·105	Bessel	0·88
C. A. F. Peters	0·142	Bessel	0·348
Johnson	0·14	C. A. F. Peters	0·349
O. Struve	0·119	C. A. F. Peters	0·360
O. Struve	0·161	Pogson	0·384
Maln	0·154	Johnson	0·397
Brünnow	0·212	Woldstedt	0·523
Brünnow	0·131	O. Struve	0·509
Hall	0·1556	Anwers	0·564
Hall	0·2080	Hall	0·4783

The excellence of the observations, the character of the instrument, and the carefulness and skill of the reductions, seem to justify our having unusual confidence in Professor Hall's work and results. H. A. N.

2. *Orbit of the Comet of* 1771.—Only a few of the comets that have been well observed have had a hyperbolic path assigned to them in the best definitive determination of their orbits. The comet of 1771 had, as computed by Encke, an ellipticity of 1·009368. This, though in itself not greatly different from unity, is yet larger than is usual in the few assigned hyperbolic orbits. The comet was visible for three months and through an arc of 132°. It has, therefore, been regarded as the best established instance of such a path. Encke used only six selected observations, and with his hyperbolic orbit gave also a parabola which satisfied them within reasonable errors of observation, though not as well as the hyperbola.

The question whether observations ever require us to accept the hyperbola as an actual form of orbit for any comet is of special interest. Professor W. Beebe undertook a full discussion of all the observations of this comet, to determine whether they would give the same result as the six used by Encke, whether the perturbations by the planets would modify the results, and whether any effect, and if so what effect, would be caused by reasonable variations of the later observations made at Marseilles, which were in any case subject to large errors. The results of his discussion were published in vol. v, pp. 159–176, of the Conn. Academy's Memoirs (1879). Professor Beebe concludes that hyperbolic elements (ellipticity=1·005901) should be taken as the best definitive elements of the orbit, and that while the parabolic residuals are not large enough to render the supposition of such an orbit untenable, the balance of probability is still with the hyper-

bola. He also expresses his strong belief that the difference between the residuals from the hyperbolic and from the parabolic elements can be but little reduced by any supposition of error in the Marseilles observations.

In the Vierteljahrschrift for 1881, Dr. Schönfeld discusses the memoir of Professor Beebe, points out some corrections that should be made, and expresses the belief that the original records of the observations are in existence, and can be used for the further discussion of the question.

On the 12th of October last, Professor Weiss communicated to the Vienna Academy the results of a new computation by Dr. Kreutz. In the notice in the Astronomische Nachrichten there is no indication of the materials used. The principal result is that the observations of the comet of 1771 can be satisfied by a parabola, and that there is no reason to assume a hyperbolic orbit. If this discussion shall be found to have covered the whole ground, and to have been in all respects satisfactory, it will be difficult to claim a hyperbolic orbit for any comet hitherto observed. From *à priori* considerations such orbits are to some minds very improbable, except the comets have, in coming to the sun, passed near and behind some disturbing planet. But of course such considerations must give way if there be any well-established instance of a hyperbolic cometic orbit. H. A. N.

3. *Celestial Charts made at the Litchfield Observatory of Hamilton College;* by C. H. F. PETERS. Nos. 1–20.—These charts are designed to represent portions of the sky as accurately and completely as the 13-inch refractor, which with a power of 80 in a clear sky shows stars of about the 14th magnitude, would permit.

Each chart covers 20 minutes in right ascension, and 5° in declination, with overlapping margins. The scale is 60 millimeters to a degree. The charts are limited always by the 5°, 10°, 15°, etc., and 0^m, 20^m and 40^m, so that they will easily form portions of a complete atlas. In this respect they differ from Chacornac's charts which lie along the ecliptic, and though limited by the same round numbers of minutes, are not so limited in declinations. Very little ground is common to Peters' and Chacornac's charts so far as published.

Professor Peters' charts, are in general, at some distance from the Milky Way, and are not to be strictly taken as giving a fair average density of the stars. From a count of several portions taken at random we find that a density equal to that of the charts would, if carried over the whole heavens, give nearly 5,000,000 stars.

The charts were begun in 1860, but each one has undergone a scrupulous last revision at a recent date. It is in the making of these charts that Professor Peters has discovered so many small planets. To the public he is known only by these discoveries. But the making of the charts, of which these twenty are the first instalment only, must be regarded as Professor Peters' great con-

tribution to astronomy. He has done all the work, observations, reductions, drafting, etc., without assistance, and has published the charts at his own expense for gratuitous distribution. There is a quiet expression of confidence in the accuracy and permanence of his work when he says that he wishes his charts to serve in future ages as a sure basis for drawing conclusions with respect to changes going on in the starry heavens.

OBITUARY.

TITUS COAN.—Rev. Titus Coan died on the first of December last, in his eighty-second year, at Hilo, Hawaii, where for nearly forty-eight years, he had labored as a faithful, large-hearted Christian missionary.

Throughout his residence at Hilo he had also another object of care and deep interest in the volcanic mountain at whose foot he lived. With each eruption or unusual display at Kilauea, he was the first on the ground to observe and report the movements; and three times he ascended to the scenes of the eruptions connected with the summit crater. Though not a geologist, his accounts have always been of geological value. He was the principal historian of the great eruption of Kilauea in 1840—his account appearing in the Missionary Herald for 1841 (p. 283); and also of the summit eruption of 1843 (id. 1843, and Dana's Exploring Expedition Geol. Rep., 1849, p. 209), when the flow was uninterrupted for twenty-five miles and continued for six weeks. It was after the latter eruption that Mr. Coan made the very important observation, confirmed by others and repeated in his mention of later eruptions, that Kilauea, although 10,000 feet lower in level than the summit crater, showed no change, no signs of sympathy whatever. Mr. Coan's first letter in this Journal appeared in vol. xiii (2d Ser.), 1852. After that they occur in volumes xiv (1852), xv (1853), xviii (1854), xxi (1856), xxiii (1857), xxv (1858), xxvii (1859), xxix (1860), xxxv (1861), xxxvii (1864), xl (1865), xli (1866), xliii (1867), xlvi (1868), xlvii (1869), xlix (1870), and in the 3d Series, vols. ii (1871), iv (1872), v (1873), vii, viii (1874), xiv (1877), xviii (1879), xx (1880), and xxi, xxii (1881); the first, written when he was forty years of age and the last (which is but an extract from his valued communication, because previous notices had given many of the facts) when he was eighty. Mr. Coan's life was full of activity and of great accomplishments among the people of Hawaii, and he has his reward. Honor is due his name from science for his valuable and long continued observations on the Hawaiian volcanoes.

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[THIRD SERIES.]

ART. XVIII.—*The Selective Absorption of Solar Energy*; by S. P. LANGLEY.

INTRODUCTION.

IN 1800, Sir William Herschel published his remarkable investigations, in the Philosophical Transactions, on obscure heat, in which he reached the conclusion that heat is an entity distinct from light.

This view was modified by subsequent writers into the statement that each ray has three qualities—heat, light and chemical action, while at the present time many physicists have reached the further conception that heat, light and chemical action are not so much qualities inherent in any ray, as modes of the manifestation of one common energy; or, to state this view in the broadest manner, that the same ethereal wave will give us either heat, light or chemical action, according to the absorbent nature of the substance which receives it.

These last opinions, however, cannot be said even yet to be universally accepted by physicists.

Dr. J. W. Draper long since pointed out that the maximum of heat did not necessarily lie in every case below the red (though it does so in the prismatic spectrum), and that in a normal spectrum it would be in the orange. These conclusions as to the normal spectrum were unverifiable by direct experiment by any means he possessed. He found it impossible, with the most delicate thermopiles at his command, to get

sensible heat from the grating spectrum without gathering all that lay in the two halves of it together, and could consequently only infer the result of complete measures. But it followed that if it ever became possible to measure amounts of heat so minute, these conclusions could be verified on separate rays of the diffraction spectrum.

No one, so far as I know, has hitherto succeeded in measuring the heat from a diffraction grating except in the gross; by thus concentrating, for instance, the whole upper half and the whole lower half of its spectrum upon the pile, and so reaching some results not without value, even as thus obtained, but of quite other interest than those which may be expected when we become able to measure with close approximation the separate energy of each wave-length. Having devoted many years to the study of the solar radiant heat, by means of the thermopile, I was led to hope that by my long apprenticeship to the precautions needed with this instrument and the possession of the most delicate apparatus attainable, I might succeed better than my predecessors. I found, however, that though I got results, they were too obscure to be of any great value, and that science possessed no instrument which could deal successfully with quantities of radiant heat so minute, for the average heat in the diffraction spectrum does not under the most favorable circumstances reach one-tenth that in the prismatic one, and is usually much less even than this.

Impelled by the pressure of this actual necessity, I therefore tried to invent something more sensitive than the thermopile, which should be at the same time equally accurate—which should, I mean, be essentially a "*meter*" and not a mere *indicator* of the presence of feeble radiation, and was led by nearly a year's continual experimenting to the construction of the Bolometer (*βολῄ μετρον*), an instrument, the details of whose construction are described in the Proceedings of the American Academy of Arts and Sciences, vol. xvi (1881). With this apparatus, the experiments on the diffraction spectrum were resumed: the first entirely unquestionable evidence of measurable heat, in a width so small as to be properly described as linear, having been obtained on October 7, 1880. Nearly the whole year 1880 passed in modifications of the instrument, or in the making of these measures which gave promise from the first of bringing results of value.

It will be seen that they afford almost all the experimental evidence the subject admits of, that every ray, whether lying in the "chemical," "visible" or "heat" region, is capable of making itself known as heat; and that the maximum of heat in the normal spectrum is near the yellow.

Further, by taking all the observations twice daily, at times

when the atmospheric absorption is very different, we are able to calculate (for the first time), the amount of this absorption for each separate spectral ray. These researches are necessarily long and difficult, but they have led to some very unexpected results. The reader who wishes to pass at once to these results will find them in the Summary at the close of this memoir.

Preliminary Observations.

The measurements with the grating possess the inestimable advantage of enabling us to fix the wave-length of every ray measured; but, while the heat in the grating spectrum is, as has just been said, at best, less than one-tenth that in the prismatic, the latter is itself, when taken in portions so narrow as to be approximately homogeneous, almost insensible. The difficulties of measuring heat with the grating are greatly complicated by the overlapping of the spectra. In these first measures, which were carried to a wave-length of one one-thousandth of a millimeter,* I have employed two of the admirable gratings of Mr. Rutherfurd, one containing 17,296 lines to the inch, or 681 to the millimeter; and one, half that number, both ruled upon speculum metal.

I have used a slit at a distance of 5 meters, without any collimator, and have kept the grating normal to the optical axis. It will be seen then that the rays have passed through no absorbing medium whatsoever, except the sun's atmosphere and our own.

The rays from the grating fall upon a concave speculum (whose principal focal distance is about 1 meter), and from this are concentrated upon the mouth of the bolometer, forming a narrow spectrum, which passes down the case of the instrument and falls upon the bolometer thread. As this thread moves along the spectrum parallel to the Frauenhofer lines its coincidence with one of them is notified by a lowering of its temperature and a deflection of the galvanometer. The instrument is of course equally sensitive to the invisible radiation as to the visible. It is important to observe that no screen is interposed between the bolometer and the grating, for the temperature of the screen itself, as it is replaced or withdrawn, will certainly affect such measurements as these. Through the whole course of the experiment the bolometer is uninterruptedly exposed to radiations from the grating, whether reflected by it or emanating from its own substance. The interruption of the solar radiation is effected at the other end of the

* Through these measures the unit of wave-length will be the *micron* (μ)= $\frac{1}{1000}$ millimeter, or 10,000 times the unit of Ångström. Thus the wave-length of Frauenhofer's "A" is here written $0^{\mu}{\cdot}76$.

train, 5 meters beyond the grating itself. In the gratings employed one of the second spectra is very feeble, or almost lacking. The rays of the second spectrum are necessarily superposed on those of double the wave-length in the first; and as all evidence of solar radiation in the most sensitive apparatus at the sea-level dies out near $\lambda = 0^{\mu}\cdot3$ in the ultra violet, it follows that we can measure down in the first spectrum as far as $\lambda = 0^{\mu}\cdot6$, or in fact further, without any fear whatever of our results being affected by the underlying second spectrum, even if that were a strong one. Underlying $0^{\mu}\cdot7$, which is near the limit of the red in the first spectrum, is $0^{\mu}\cdot35$ in the second, where heat is practically still negligable. We have, therefore, knowing the amount of heat in the second spectrum at $0^{\mu}\cdot5$, and knowing that our ultimate point of measurement at $1^{\mu}\cdot0$ in the first spectrum overlies $0^{\mu}\cdot5$ in the second, the means of asserting with confidence that no considerable error can be introduced from this cause, after an allowance has been made here for the minute effect of this second spectrum. An allowance is also made to reduce the effect to that which would have been observed with a grating so coarsely ruled as to cause no considerable deviation from the slit of any portion of the spectrum measured. The bolometer (in a constant position relative to the concave mirror such that the optical axis of the latter bisected the angle between its central thread and the center of the grating), was moved, together with the mirror, by a tangent screw in arc, so that the spectrum appeared to traverse its face.

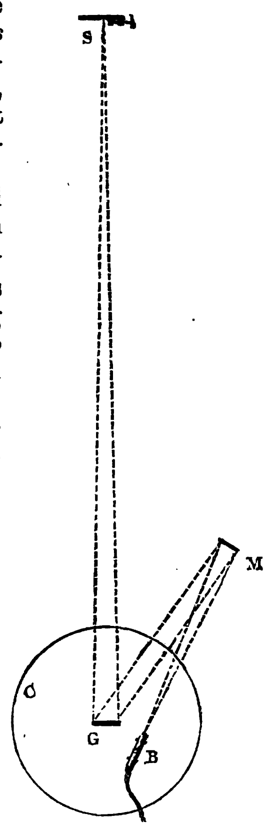
The actual angular deviation of any ray under examination was obtained from a divided circle on which the arm carrying both mirror and bolometer moved. A particular description is not given, as the whole apparatus was replaced by a more perfect one later. That actually used will be intelligible by the sketch, fig. 1, where S is the slit, G the grating, M the concave mirror, B the bolometer, and C the divided circle.

The light came from the silvered mirror of a heliostat, passing through the slit at a distance of about 5 meters from the grating, which was bolted immovably above the center of the circle of a massive dividing engine, with the grating's plane always perpendicular to the line joining its center and the slit. The mirror and the bolometer, with their attachments, were fastened to this movable circle.

An allowance has been made for the absorption of speculum metal and silver, but the absorption of the iron strips of the bolometer has only been indirectly allowed for. This has been done by comparison with the action of a bolometer with lamp-

blacked surface. It will be seen hereafter that the whole experiment has been repeated with a lampblacked bolometer without in any way affecting the results. The wave-lengths are derived from the measured angles by the use of the formula $ns\lambda$ = sine i + sine r, where n is the order of the spectrum, s the space between the lines of the grating, λ = the wave-length of the radiation, i the angle of incidence (in the present instance 0°), and r the angle of diffraction.

1.



In the early observations it appeared from the examination of the diffraction spectrum up to $\lambda = 1^{\mu}\cdot 0$ that the energy in the invisible part as far as this, was much less than in the visible. Nothing definite is even at this time known to physicists as to the extent of the normal solar spectrum; but the prismatic spectrum is still very commonly supposed to be limited by theoretical considerations to an extent little greater than this; and one of those most conversant with the subject has treated this wave-length (i. e. $1^{\mu}\cdot 0$) as marking the limit of everything known to exist.*

It seemed at first then improbable that the heat below the red should materially exceed or even equal that above it; for this would demand (since the heat shown by the last ordinate at $\lambda = 1^{\mu}\cdot 0$ is very small) an extension of the curve of heat, as obtained from the grating, to a distance enormously beyond the furthest

* Draper, "On the Phosphorograph of a Solar Spectrum, and on the Lines in the Infra-red Region." Proceedings of the American Academy, vol. xvi, p. 233, Dec. 1880. He asks, "Do we not encounter the objection that this wave-length $10\cdot750^{m-10}$ (the limit of Captain Abney's map) is altogether beyond the theoretical limit of the prismatic spectrum?" Previous measurements of heat had, it will be remembered, been made by comparing its total amounts, in the visible and invisible prismatic spectrum, which gives us no knowledge as to wave-lengths in any case, and wave-lengths in the dark-heat region, had been estimated, by hazardous extra-polations from contradictory formulæ—formulæ which profess a theoretical basis, but contradict each other. Thus Müller finds by Redtenbacher's formula a wave-length of nearly $5^{\mu}\cdot 0$ for the extreme solar heat rays, Draper (as we have just seen) a wave-length of but $1^{\mu}\cdot 0$ for the same rays, etc. All these formulæ (Briot's, Cauchy's, etc.) agree well with the observations in the visible spectrum, which they have in fact been originally deduced from. They contradict each other thus grossly when used for extra-polating the place of the extreme infra-red rays, whose real place we give later from actual measures.

limit then assigned to the normal spectrum by experiment. The writer's further investigations, however, led him to believe that this immense and unverified extension really existed, and to thus confirm by independent means the statements of Tyndall and others, as to the great heat in this region. He was unable to determine its exact limit with the grating as then used, on account of the over-lapping spectra, but was, some two years since, led, from experiments not here detailed, to suspect the existence of solar heat at a distance of nearly four times the wave-length of the lowest visible line, $A(\lambda=0^{\mu}\cdot76)$ or at $\lambda=3^{\mu}\cdot0$.

We receive all the solar radiations through an absorbing atmosphere, and it is of the first consequence to determine the rate of this selective absorption for each separate ray. This has (owing to the difficulties before alluded to) never yet been, so far as I know, attempted. It forms a prominent part of the present design.

The great difficulty in this investigation, after the provision of a sufficiently delicate heat-measurer, lies in the varying amount of radiant energy which our atmosphere transmits, even for equal air-masses. The solar radiation is itself sensibly constant, but the variations in the radiant heat actually transmitted are notable, even from one minute to another under an apparently clear sky. The bolometer, in fact, constantly sees (if I may use the expression) clouds which the eye does not. That these incessant variations are in fact due to extraneous causes and not to the instrument itself, has been abundantly demonstrated by measurements on a constant source of heat.

Those taken, for instance, on a petroleum lamp, so placed as to give nearly the same galvanometer deflection as the sun did, were found to indicate a probable error, for a single observation, of less than one per cent.

The variations from minute to minute (under a visually clear sky) amount frequently to ten times the probable instrumental error, and they can only be eliminated by repeating the observations a great number of times on many different days. Actually, twenty-nine such days' observations have been made (as appears below) in the preliminary series, but it would be an error to suppose that this number was obtained without the sacrifice of a still larger number on which the apparatus was prepared, and the day spent without results, owing to the still more considerable atmospheric changes between morning and afternoon. Even of the twenty-nine days cited, and which may be considered exceptionally fair, it will be seen that in only ten cases did the sky continue sufficiently constant in the morning and afternoon to allow complete series to be taken.

It will be understood that we aim to make at least two sets of measures throughout the spectrum daily, one when the rays

have been little absorbed (at noon), the other when they have been greatly absorbed (in the morning or afternoon). The mass of air through which the rays pass is taken proportional to secant, ζ for zenith distances less than 65°, and for those greater to $\frac{\cdot 0174 \text{ tabular refraction}}{\text{cos. apparent altitude}}$, and in both cases to the actual barometric pressure. It is expressed in units, each of which is represented by the pressure of one decimeter of mercury at the sea-level. As the barometric pressure there is $7{\cdot}6^{dm}$, $t^{7\cdot 6}$ gives the transmission for an entire atmosphere. The coefficient of transmission then for one atmosphere ($t^{7\cdot 6}$) is the proportion of the radiation transmitted by a sun in the zenith to an observer at the sea-level, and this is here shown to vary greatly for each ray. Thus by reference to table III, we find of three solar rays whose wave-lengths are ·375, ·600, ·1,000, that of the ray whose wave-length is $0^{\mu}{\cdot}375$ (in the ultra violet) 61 per cent of the original energy would be absorbed and 39 transmitted, of wave-length $0^{\mu}{\cdot}600$ (in the orange) 36 per cent would be absorbed and 64 transmitted, of wave-length $1^{\mu}{\cdot}000$ (in the infra-red) 20 per cent is absorbed and 80 transmitted, etc.

Allegheny Bolometer Observations on the Solar Diffraction Spectrum previous to Mt. Whitney Expedition.

The following list shows the dates at which bolometer observations were made at Allegheny up to June, 1881, for the measurement of heat in the spectrum and the determination of atmospheric transmission, by the comparison of noon and afternoon measures. Those days on which noon measurements were taken which were rendered useless for this purpose by subsequent changes in the condition of the sky or by other causes are indicated by an asterisk. It will be seen that of twenty-nine days of observation only ten could be fully utilized.

Dates: 1880, Nov. 12,* Dec. 11,* Dec. 18.* 1881, Jan. 12,* Jan. 18,* Jan. 28, Feb. 2, Feb. 3,* Feb. 5,* Feb. 17, Feb. 19,* Feb. 22,* Feb. 26,* Mar. 2,* Mar. 10.* Mar. 11,* Mar. 25,* Mar. 28,* Apr. 7,* Apr. 16,* Apr. 22, Apr. 23, Apr. 28,* Apr. 29, Apr. 30, May 4,* May 26,* May 27,* May 28.

The following table gives the observed galvanometer deflections reduced to a scale on which the readings are proportional to the current passing through the galvanometer.

$d_{\prime}$ = galvanometer deflection with high sun
$d_{\prime\prime}$ = " " " low sun.

TABLE I.

$\lambda =$		$0^{\mu}.375$	·400	·450	·500	·600	·700	·800	·900	1·000
Jan. 28, 1881	$d_{,}$	--	101	--	374	383	320	221	144	102
	$d_{,,}$	--	43	--	167	268	215	221	116	78
Feb. 2	$d_{,}$	34	80	215	289	307	293	175	--	93
	$d_{,,}$	3	20	61	104	141	195	91	--	47
Feb. 17	$d_{,}$	23	62	120	232	260	227	188	--	71
	$d_{,,}$	8	25	58	110	133	151	80	--	39
Apr. 22	$d_{,}$	19	43·5	154	236	262	239·5	177·5	123·5	98
	$d_{,,}$	6·5	17	63	119·5	171·5	180·5	122·5	89·5	84
Apr. 23, A. M.	$d_{,}$	--	59	152	206	263	227	191	121	94
	$d_{,,}$	--	41	124	189	258	257	187	122	96
Apr. 23, P. M.	$d_{,}$	--	59	152	206	263	277	191	121	94
	$d_{,,}$	--	32	103	124	188	198	140	80	66
Apr. 29, A. M.	$d_{,}$	13	29	113	151	235	235	139	100	89
	$d_{,,}$	10	22	65	126	156	197	135	93	86
Apr. 29, P. M.	$d_{,}$	13	29	113	151	235	235	139	100	89
	$d_{,,}$	5	8	49	62	107	116	72	58	66
Apr. 30	$d_{,}$	21	55	121	186	245	259	175	119	90
	$d_{,,}$	18	33	97	148	220	232	166	97	80
May 28	$d_{,}$	8	34	99	109	144	134	89	64	52
	$d_{,,}$	--	2	9	27	52	66	61	33	39

The next table gives the sun's position, and the corresponding air-mass for each series in the previous table.

In this table, β denotes the reading of the barometer and M is determined from the formula

$$M = \frac{\cdot 0174 \times \text{tabular refraction}}{\text{cos. app. altitude.}}$$

TABLE II.

Date of Observation.	High Sun.				Low Sun.			
	Sun's Hour Angle.	Sun's Zenith Distance.	Barometer ($\beta_{,}$).	Air Mass ($M_{,}\beta_{,}$).	Sun's Hour Angle.	Sun's Zenith Distance.	Barometer ($\beta_{,}$).	Air Mass ($M_{,}\beta_{,}$).
	h m	° ′	dm		h m	° ′	dm	
Jan. 28, 1881	0 00	58 29	7·45	14.25	2 57	71 28	7·45	23·24
Feb. 2	0 09	57 09	7·39	13·63	3 00	70 45	7·39	22·24
Feb. 17	0 38	52 57	7·43	12·33	2 56	66 09	7·42	18·25
Apr. 22	0 12	28 13	7·36	8·35	4 36	66 22	7·36	18·32
Apr. 23, A. M.	0 11	27 49	7·40	8·37	2 45	45 30	7·40	10·56
Apr. 23, P. M.	0 11	27 49	7·40	8·37	4 26	63 57	7·40	16·85
Apr. 29, A. M.	0 06	25 50	7·35	8·17	3 11	48 46	7·35	11·15
Apr. 29, P. M.	0 06	25 50	7·35	8·17	5 23	73 36	7·35	35·73
Apr. 30	0 04	25 31	7·41	8·21	3 54	56 31	7·41	13·43
May 28	0 11	19 03	7·32	7·75	5 33	71 14	7·32	22·33

By combining the high and low sun observations of each day separately, coefficients of atmospheric transmission are obtained by using the formula

$$\log t = \frac{\log d_{,,} - \log d_{,}}{M_{,,}\beta_{,,} - M_{,}\beta_{,}}$$

where t is the coefficient of vertical transmission by air at a barometric pressure of one decimeter. A tabular statement of these coefficients has been prepared, but the average or adopted value only is here given.

TABLE III.

$\lambda=$	·375	·400	·450	·500	·600	·700	·800	·900	1·000
Adopted t	·884	·892	·909	·923	·942	·955	·965	·970	·971
$t^{7\cdot6}$	·392	·420	·485	·544	·636	·705	·763	·794	·799

It is important to notice that (contrary to a generally received opinion), *the transmissibility of the atmosphere is here found to be greatest for the infra-red rays.*

All good noon observations have been reduced to a uniform battery current of 0·25 webers, and the results, arranged in two sets, the first for winter and the second for spring measures.

These tables are not here given but the average results are as follows:

TABLE IV.

$\lambda=$	·375	·400	·450	·500	·600	·700	·800	·900	1·000
Winter $d_{,}$ (mean of 7 series)	31	88	190	294	328	259	172	111	91
Spring $d_{,}$ (mean of 9 series)	18	57	139	218	281	271	188	121	94

The average noon deflections for winter and spring, given in the previous table, require further correction; first, for the over-lapping portion of the (weak) second spectrum, which is considered from provisional experiments to have here an intensity one-thirtieth that of the first. Second, for the selective absorption by silver surfaces. Third, for the selective absorption by one surface of speculum metal. Fourth, for the diminution of heat in the diffraction spectrum with increase of the angle of diffraction, which is here provisionally taken as proportional to secant r. The selective absorption by the material of the bolometer is here treated as negligable.

These corrections are expressed as factors by which the uncorrected deflections are to be successively multiplied, except in the case of the first correction which is to be subtracted. (The second and third corrections have been determined here by special researches on metallic absorption, which will form the subject of a separate memoir).

The researches here on the selective absorption of lampblack, it should be added, are incomplete and the value given may be yet subject to a further correction due to this error.

TABLE V.

$\lambda=$ Correct'n	·375	·400	·450	·500	·600	·700	·800	·900	1·000
I (subtr.)	0	0	0	0	0	0	$\frac{1}{30}\times d_{.40}$	$\frac{1}{30}\times d_{.45}$	$\frac{1}{30}\times d_{.50}$
II (factor)	3·005	2·067	1·606	1·448	1·301	1·227	1·192	1·166	1·145
III "	2·000	1·923	1·802	1·695	1·550	1·460	1·408	1·389	1·370
IV "	1·034	1·039	1·051	1·064	1·096	1·138	1·193	1·266	1·366

We have been measuring thus far "heat" by which we mean the solar energy as interpreted by certain agents (that is, silver, lampblack, etc.), in our apparatus. In the degree in which we have above eliminated the selective absorption peculiar to each of these agents, are we entitled to speak of the resultant values, as proportional to the solar energy itself. We do not suppose ourselves to have accomplished so untried and difficult a task with exactness, but regard these curves as useful as a first approximation to the absolute energy curve.

These corrections being applied, the final values of noon deflections at Allegheny become

TABLE VI.*

	·375	·400	·450	·500	·600	·700	·800	·900	1·000
$\lambda=$	·375	·400	·450	·500	·600	·700	·800	·900	1·000
$d_{,}$ (cor.) winter, 1881,	192·6	363·4	579·3	767·9	724·9	527·9	338·3	215·4	173·6
$d_{,,}$ " spring, 1881,	111·9	235·4	423·7	569·6	621·0	552·5	372·3	238·0	234·6

The mean air mass for winter = 13·88
" " " spring = 9·33

We now proceed to the calculation of the energy outside the atmosphere for homogeneous rays with the data which have been given. For this purpose we have used the formula

$$\text{Log E} = \log d_{,} - \text{M}_{,}\ \beta_{,} \log t.$$

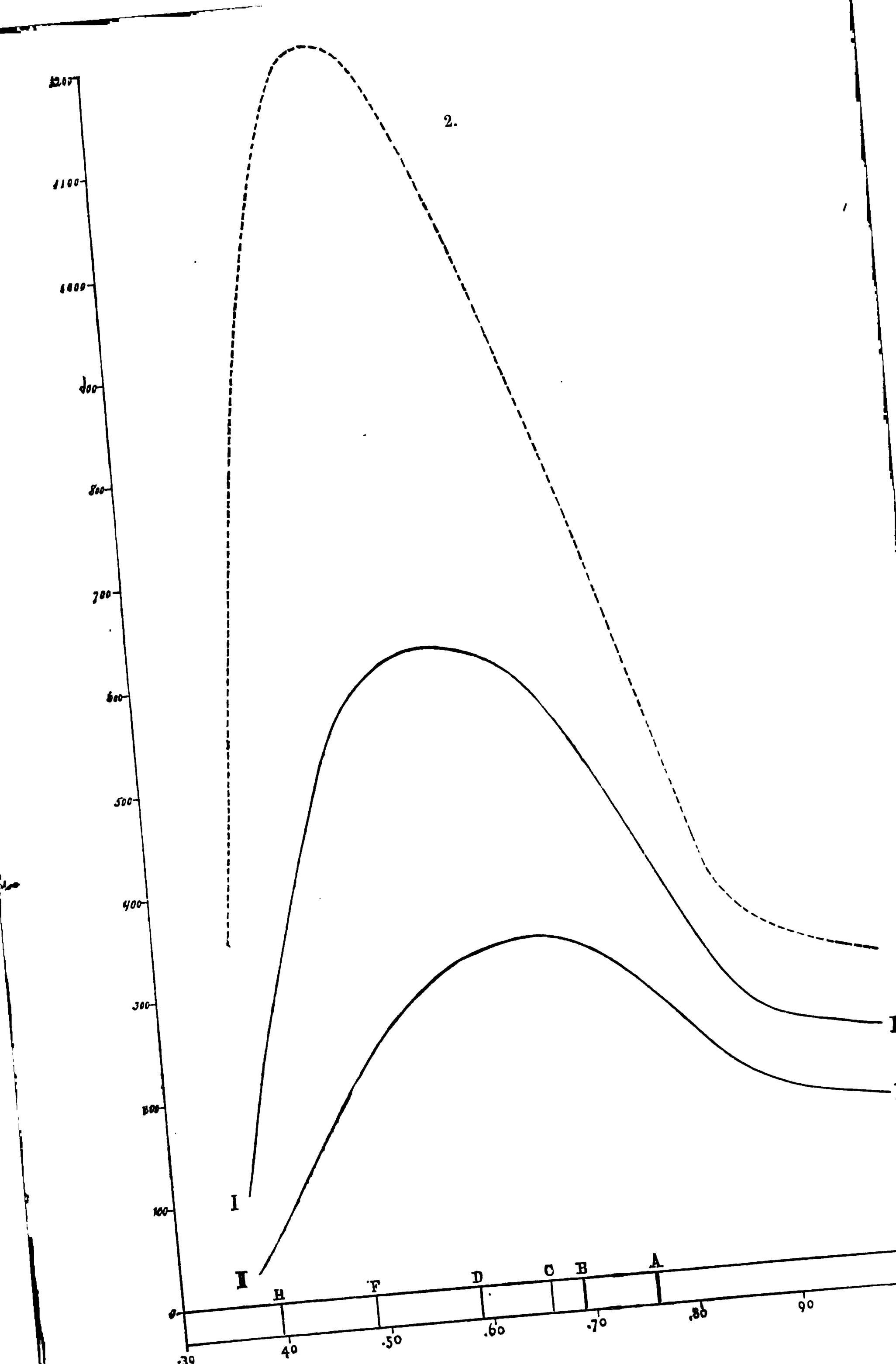
Where E is the energy in any ray outside the atmosphere (i. e. before telluric absorption), $d_{,}$, the average galvanometer deflection at noon for the same ray, $\beta_{,}$, the barometer pressure in units of one decimeter, or the mass of air in the vertical column; $\text{M}_{,}\ \beta_{,}$ the corresponding air-mass for the sun's zenith distance at noon, and t the adopted coefficient of transmission.

The following table has been prepared with the values observed in the spring of 1881, using mean coefficients of transmission, to show the relation between energy outside the atmosphere and that for high and low sun at Allegheny, the various actual absorbing air-masses at the low sun observations being reduced to a uniform value, double that at high sun.

TABLE VII.

$\lambda=$	·375	·400	·450	·500	·600	·700	·800	·900	1·000
E = energy before absorption,	353	683	1031	1203	1083	849	519	316	309
$d_{,}$ = energy after absorption (corrected high sun),	112	235	424	570	621	553	372	238	235
$d_{,,}$ = energy after absorption (corrected low sun),	27	63	140	225	311	324	246	167	167

* It will be seen that although the winter absorbing air-mass was nearly half as large again as in the spring, the heat received from the shorter wave-lengths was actually greater in the winter. It appears probable, then, that the transmissibility of the atmosphere for the light-producing radiations is relatively greater in winter than in spring. As this effect may be connected in some way with the unequal prevalence of atmospheric moisture at the two seasons, it may be well to state that the tension of aqueous vapor during the winter observations was in the neighborhood of 2 millimeters, in the spring of 8 millimeters.


2.
1100
800
700
500
400
300
100
0
I
II
H
F
D
C
B
A
·30
40
·50
·60
·70
·80
90

E can be computed from $d_{\prime}$ and $d_{\prime\prime}$ by the formulæ already given, and with these values the curves in fig. 2 have been plotted.

The middle curve (I) is that at high sun. Except for the heat below wave-length ($1^{\mu}\cdot0$), the area of the curve may be considered to represent the heat actually observed by the actinometers, at noon, as presently given.

The lower curve (II) is that at low sun. Its area is proportional to the heat received when the sun shone through double the absorbing air-mass that it did at noon.

The upper dotted curve is "the curve outside the atmosphere." Its area will give the heat, which would be observed if our apparatus were taken wholly above the absorbing air, and the distribution of this heat (energy) before absorption. Knowing the values in calories corresponding to the middle curve, we readily obtain the absolute heat before absorption (the Solar Constant).

It should be noticed that if we had attempted to deduce this latter value, by applying our logarithmic formulæ directly to ordinary actinometric observations (i. e. to observations where only the indiscriminate effect of all heat rays is noted by the thermometer) made at high and low sun, we should have obtained a quite different result. This has been the usual process, but it can never be a correct one; for these exponential formulæ are in theory only applicable to homogeneous rays, and the departure from theory here involves an error which is demonstrably large.

The above values (in table VII) are relative only. To obtain absolute ones we have now to combine this result with the actual measurements of solar radiation in calories, or other units furnished by actinometers under approximately the same conditions. We shall at the same time thus obtain a preliminary value for the Solar Constant. Taking the mean of our observations with the Violle and Crova actinometers on clearest days, we have 1·81 calories observed at Allegheny in March, 1881. This is the absolute amount of heat represented by the area of a completed "high sun" curve.

To this result, the energy distributed through the whole spectrum has contributed, while our bolometer measurements in the diffraction spectrum end at wave-length $1^{\mu}\cdot00$. Nevertheless, since we do in fact know from subsequent measures (to be given later) where the effective spectrum ends, we can by the aid of these later measures prolong the curves and obtain their relative areas with close approximation. In this way we determine, by measuring the charted areas, and making allowance for the (here) uncharted area below $\lambda = 1^{\mu}\cdot0$:

Area Outside Curve above = $1^{\mu}\cdot000$	47·26
Area Outside Curve below = $1^{\mu}\cdot000$	26·49
Total	73·66
Area High Sun Curve above = $1^{\mu}\cdot000$	26·96
Area High Sun Curve below = $1^{\mu}\cdot000$	20·00
Total	46·96

The ratio of these areas is $\frac{\text{Area Outside Curve}}{\text{Area High Sun Curve}} = \frac{73\cdot66}{46\cdot96} = 1\cdot569$

We have, then, adopting 1·81 cal. as the solar radiation at Allegheny with clear sky, 1·81 cal. $\times$ 1·57 = 2·84 calories as an approximate value of the Solar Constant.

In all these observations, the object has been to avoid the registering of small variations analogous to the Frauenhofer lines, and to give only the general distribution of the energy. The mapping of the interruptions of the energy caused by visible or invisible lines or bands forms a distinct research, and the results are given later in the present article.

We find from these preliminary observations, that the maximum energy in the normal spectrum of a high sun at the earth's surface is near the yellow, and that the position of the maximum of heat does not in fact differ widely from that of the maximum of light. It has been long known that certain ultra violet and violet rays were much absorbed, but it has been supposed that the absorption increased also in the infra-red, so that the luminous part of the spectrum was on the whole the most transmissible.

But we see here, not only how enormous the absorption at the violet end really is, but that the light rays have suffered a larger absorption before they reach us than the "heat" rays (i. e. than the extreme red and infra-red rays) a conclusion opposed to the present ordinary opinion, and if true, of far-reaching importance. For if this "dark" heat escapes by radiation through our atmosphere more easily than the luminous heat enters, our view of the heat-storing action of this atmosphere, and of the conditions of life on our planet must be changed. Within the limits of the present charts the "dark" heat apparently does so escape.

We can from the data now gathered as to the rate of absorption for each ray, compute the value of the heat or energy before absorption (the solar constant) by a new process which is in strict accordance with theory. This preliminary value indicates that the true solar constant is larger than that commonly given. The ratio of the dark to luminous heat has been so wholly changed by selective absorption that we must

greatly modify our usual estimates not only of the sun's heat radiation but of his effective temperature.

The sun to an eye without our atmosphere would appear of a bluish tint.

In spite of the care with which the experiments on which the above conclusions rest have been conducted, owing to the importance of the subject, and to their departure in some respects from received opinion, it seemed desirable to repeat them under conditions differing as much as possible from those in which they were made. If the preceding conclusions are sound, we ought to find like results, by actually ascending to a great height, and directly measuring there, as well as below, the absorptions which each ray has actually undergone.

Expedition to Mount Whitney.

In July, 1881, an expedition, fitted out, and instrumentally equipped at the Allegheny Observatory, proceeded in the writer's charge but with the aid of transportation furnished by the War Department and under the official direction of General W. B. Hazen, U. S. A., Chief Signal Officer of the Army, to Mt. Whitney in Southern California, where these observations and others were repeated at two contiguous stations at very different absolute altitudes. The results will shortly appear in an official publication (some of the drawings prepared for which have been used for the present memoir, by the kind permission of General Hazen). At present it is sufficient to say of them that the conclusions just rehearsed were confirmed and extended.

While on the mountain, at an elevation of 13,000 feet, a hitherto unrecognized extension was observed by the bolometer of the infra-red *prismatic* spectrum in the vicinity of the great absorption band, marked on our prismatic chart as *Ω* and beyond it, and on the return to Allegheny it was found that this last observation could still be continued in our lower atmosphere. The generosity of a citizen of Pittsburgh had enabled the observatory to provide for the expedition several pieces of special apparatus. Among these was a Foucault Siderostat, of the dimensions of that at the Paris Observatory, but of a much improved design; and a special apparatus (the spectro-bolometer), to enable the deviations of the invisible rays to be measured with an error of less than a minute of arc, etc., and this apparatus has been used in the new research we now describe. (The Siderostat was made by A. Hilger of London, the spectro-bolometer by W. Grunow, of New York, and both have been very satisfactory.)

Sir William Herschel, in 1800,[1] showed that heat extended below the visible spectrum. He found that about one-half the spectrum consisted of obscure and one-half of luminous heat. Seebeck and Melloni in various memoirs showed that the disposition of the heat depended on the substance of the prism, and that this was due in part to its absorption.

In 1840, Sir John Herschel[2] gave a thermograph of the invisible spectrum indicating unequal absorption below the red.

Dr. J. W. Draper, in 1842,[3] observed three wide bands in this region which he called α, β, γ. In 1846, Messrs. Foucault and Fizeau appear to have observed the same lines. Dr. Draper[4] states that prior researches lead him to believe that the hottest part of the normal spectrum will be found in the yellow.

Dr. J. Müller[5] gives a construction showing how we may, from the distorted prismatic spectrum, obtain the true or normal dispersion. Dr. Müller conjectures that the wave-length of the extremest infra-red ray is about $1^{\mu}{\cdot}8$, and from his diagram it appears that nearly two-thirds of the heat is below the visible portion.

Tyndall[6] gives the position of the maximum of heat in the prismatic spectrum and estimates the invisible radiation of the sun to be twice the visible.

In 1871, Lamansky[7] gave a drawing showing three gaps in the continuity of the infra-red curve as observed by the thermopile. Lamansky repeats the usual statement that these infra-red rays are strongly absorbed by the atmosphere.

In 1879, Mons. Mouton[8] in a valuable memoir, speaks of there being four known bands in the infra-red whose wave-lengths are $0^{\mu}{\cdot}85$, $0^{\mu}{\cdot}99$, $1^{\mu}{\cdot}23$, $1^{\mu}{\cdot}48$, and gives $1^{\mu}{\cdot}77$ and $2^{\mu}{\cdot}14$ as wave-lengths he supposes himself to have identified.

If our charts be correct there is no considerable band at $1^{\mu}{\cdot}48$, and $2^{\mu}{\cdot}14$ which he marks as the termination of the spectrum is in fact the hottest point in its neighborhood.

It seems probable, however, that he had perceived by his ingenious method the existence of the band whose wave-length on our charts is marked $1^{\mu}{\cdot}37$, and in doing so had reached the furthest band then certainly observed.

Captain Abney,[10] in 1880, mapped by photography the infra-red prismatic spectrum as far as wave-length $1^{\mu}{\cdot}075$ with a precision and completeness till then wholly unknown, besides

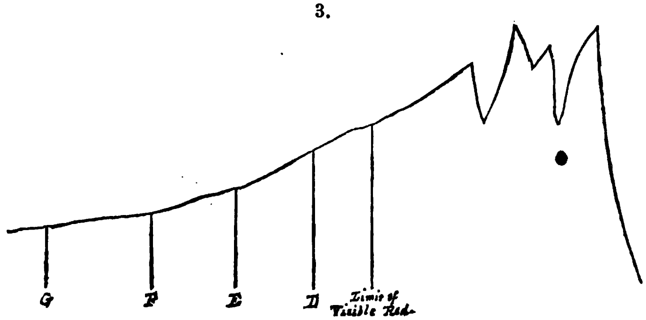
[1] Phil. Trans., 1800. [2] Phil. Trans., 1840. [3] Phil. Mag., May, 1843.
[4] Phil. Mag., 1857. [5] Poggendorf's Annalen, vol. cv. [6] Phil. Trans., 1866.
[7] Monatsbericht Konig. Acad. Wissenschaft., Berlin, 1871. Phil. Mag., 1872.
[8] Comptes Rendus, vol. lxxxix, p. 298.
[9] Comptes Rendus, vol. lxxxviii, p. 1190. [10] Phil. Trans., 1880.

giving the wave-lengths of lines for which he derives by an extra-polation curve a position at $\lambda = 1^{\mu}\cdot240$, and indicating a band still beyond.

Captain Abney had previously published a map of the diffraction spectrum extending to $\lambda = 0^{\mu}\cdot9682$. Dr. J. W. Draper,[11] by the aid of Captain Abney's map, believes he has identified the lines α, β, γ he saw in 1842 with groups represented by Abney at $\lambda = 0^{\mu}\cdot8150$ to $0^{\mu}\cdot8350$, $0^{\mu}\cdot8930$ to $0^{\mu}\cdot9300$, and $0^{\mu}\cdot9350$ to $0^{\mu}\cdot9800$.

On our chart we have given Draper's α, β, γ according to his own locations of them. He believes these to be the same lines seen by himself, Foucault and Fizeau, and Lamansky. According to Draper, then, the lowest limit of his own or any other researches known to him in 1881, did not extend much beyond wave-length $1^{\mu}\cdot0000$. It appears to us probable, however, that Lamansky's lowest point was below this, and we give a copy of Lamansky's curve (fig. 3) which the reader can compare with the positions on our present charts.

3.



LAMANSKY.

These brief references concern only what belongs to our immediate purpose, and are not offered as a history of the subject.

Recent Observations on the Invisible Prismatic Spectrum.

After the return from Mt. Whitney, observations were taken at Allegheny with the train of apparatus used on the mountain just referred to, and on nearly every good day during the first six months of 1882. These were of such: 4 days in January, 8 in February, 9 in March, 9 in April, 9 in May, 12 in June. In all, 51 days.

[11] Proceedings of the Amer. Acad., 1881.

Very early the observations with this efficient apparatus (the result of improvements due to the previous two years' practice), showed by an accuracy not hitherto attained in such measures, the possibility of mapping the regions of the infra-red spectrum believed to have been first observed on Mt. Whitney, and which have remained hitherto unknown. The extreme narrowness of the bolometer thread (one-fifth of a millimeter), and the size of the prismatic spectrum employed, made it also possible, in spite of the condensation of the latter, to discriminate lines and gaps in its continuity which had escaped previous observation.* The spectrum, as the reader now sees it in the charts, was mapped with the intention of noting these interruptions of energy which had been in the previous research designedly neglected. The bolometer shows the *cold* in the principal visible Frauenhofer lines readily, but as their effect individually is slight it has not been indicated in the part of the visible spectrum above C.

The map reached approximate completeness early in April, 1882, after which date observations have been still continued daily, whenever possible, so that every portion of the curves here given, to the smallest inflection, has been observed from three to twenty times, and the accidental variations due to momentary interruptions of solar heat by invisible clouds have been, it is hoped, nearly eliminated.

The bolometric work, represented by the preceding 51 days' observations, may be here regarded as being divided into two classes having distinct though related objects.

1st. To determine the general *selective* absorption of the earth's atmosphere throughout the entire spectrum in connection with the observations already made here and on Mt. Whitney. For this purpose measurements have been made at the following deviations: 44° 30′, 45° 30′, 45° 53′, 46° 12′, 46° 30′, 46° 45′, 47° 30′, 48° 00′, 49° 00′, 50° 00′, 51° 00′.

All these points have been measured on, twice each, the whole forming a "series," and these "series" are observed at least twice daily: namely, at meridian, and when the air mass is approximately double that at meridian; or else three times daily—at meridian, when the mass of air traversed is approximately $1\frac{1}{2}$ times that at meridian, and again when it is approximately $1\frac{1}{2}\times1\frac{1}{2}=2\frac{1}{4}$ times that at meridian.

It will be observed by reference to the map, that the points chosen for measurement coincide, as a rule, with the summits of the energy-curve, but separate investigations are still in

* Nevertheless, as the thread, however narrow, is not absolutely linear, it feels the cold before its center coincides with the center of the line. The interruptions of the energy curve are thus in fact all in a slight degree too wide, especially at the commencement of each depression, and it is probable that the bands we have marked are really due to an aggregation of finer lines.

progress on the nature of the absorption in the intervals, to determine whether the newly-observed bands are of solar or terrestrial origin. The part of the spectrum included extends from $\lambda = 0^{\mu}\cdot383$ (above H in the violet), to $\lambda = 2^{\mu}\cdot28$ (in the newly-observed infra-red region, about two octaves below Frauenhofer's B).

(As we can, in fact, obtain evidence of heat in ultra-violet waves whose length is little more than $0^{\mu}.3$, the length of the solar spectrum as now observable by the bolometer is between 3 and 4 octaves.)

The distant slit is separately exposed at each observation, and the extremity of the full swing of the galvanometer needle is read. In all these measures the galvanometer is used in the same condition of sensitiveness. The slit is opened to a constant width of 2^{mm}* (except in measuring the very feeble energy at the most refrangible end of the spectrum, where the width has been increased without prejudice to accuracy, owing to the corresponding prismatic expansion of the spectrum itself). The same bolometer is used, as a rule, having for this purpose 1^{mm} effective aperture (except in measurements at the most refrangible end of the spectrum, where the full aperture of the bolometer is used).

These observations on the absorption of different air masses, for each spectral ray, evidently furnish means for determining the curve outside the atmosphere, by the method already indicated. They also, of course, give us the means of making a map of the whole spectrum, but their use for this latter purpose is incidental.

2d. The other class of observations is for the special purpose of making a spectral map, extending from the line C to the lower limit of the infra-red.

This is carried on by means of the linear bolometer consisting of a single strip $\frac{1}{8}^{mm}$ wide. In this second class of observations, a rough map of the whole infra-red spectrum having been prepared, a very limited part of the spectrum (such as that included between 15′ of deviation) is gone over several times in the course of one day, the measurement being repeated on every single minute of arc, with a separate opening and closing of the slit, and a record made of the full swing of the galvanometer needle for each observation.

These observations are entered numerically, and corresponding charts made on large sheets of section paper. The same narrow region will thus be gone over also on different days, and the different charts subjected to a very rigid examination,

* It will be remembered that, the actual distance of the slit being 5 meters, this aperture subtends an angle little greater than one minute of arc.

so that every feature which is not common to them all is rejected or reëxamined, and in this manner the whole spectrum is studied. These original charts are on a scale four times as large linearly as that the reader now sees (Plate III).

In addition to this, on some clear days, tracings have been made upon the chart directly corresponding to the movements of the galvanometer needle; that is to say, the observer at the spectro-bolometer has moved the bolometer through the whole spectrum by means of the tangent screw; the slit has been left permanently open so that the bolometer has been constantly exposed; and the observer at the galvanometer, seeing the needle moving, as a hot or cold part of the spectrum passes over, calls the deflection of the galvanometer corresponding to each minute of arc, while a third person plots the same on section paper. In this way as many as eight curves like those here given of the prismatic spectrum, have been obtained between noon and sunset on one day, giving a picture of the action of the selective absorption of the atmosphere in every part of the spectrum, as the rays of the sinking sun pass through greater depths of air. This third method—very useful when, as in this case, many observations have to be taken in a short time—is nevertheless less accurate than those before described.

A careful bolometric and also optical setting is made on some well known line, usually C, at least once daily, to make sure that the adjustment of the instrument is equally accurate for the visible and invisible rays.

Description of the Apparatus.

The rays of the sun are reflected horizontally from the mirror of the large Foucault siderostat through an aperture in the north wall of the observatory, and received upon a plate with a slit, whose jaws, moving each way from the center by a micrometer screw, can be regulated so as to allow a beam of any desired size to pass. 4½ meters from this slit, at the distance of its principal focus, is a collimating lens, L, of a special kind of flint glass, which has been found nearly transparent to all the invisible rays measured. This lens and the slit are fitted into opposite ends of a tube, T, 4½ meters long, held by suitable y's. The beam of rays from the slit, now rendered parallel by the collimator, next falls upon a prism,* P, of the same kind of glass as the lens, supported on a circular adjustable

* This prism, whose optical properties are in every way excellent, was made by Mr. A. Hilger, of London. Its principal constants are as follows: size of polished faces, 53^{mm} by 49^{mm}; specific gravity, 2·895; refracting angle, 62° 34′ 43″; index of refraction for D, line 1·5798; index of refraction for H, line 1·6070. (A rock salt prism of nearly equal size and great purity, as well as prisms of quartz and spar, have been used to determine the absorption of the glass for each ray, visible and invisible.)

table over the vertical axis of the massive instrument we have called provisionally the spectro-bolometer.

Whatever the sensibility of the apparatus to heat, it is evident that we cannot accurately map the narrow spectral limits between contiguous heat and cold, unless we can fix their position with exactness. Especially when we consider that these rays are invisible, and that the whole process may be compared to a patient groping in the dark, does the need of an instrument which will record the precise point where a hot or cold line was felt, become obvious. This is the object of the spectro-bolometer, which, as well as other apparatus mentioned here, will be described more particularly in the account of the observations made on Mount Whitney. (It was made by W. Grunow, of New York, from the writer's design.)

Two long arms, A, A′, turn independently about the above mentioned axis, the angle between them being measured by a graduated circle with two verniers reading to 10″. One of these arms is directed toward the slit, and the other toward the spectrum formed by the light on leaving the prism. This latter arm carries at its extremity a concave mirror, M, of 98 centimeters focus, and on either side of the prism an accurately planed track directed toward the center of the mirror, on either of which slides a carriage with y's. Into these y's, at B, drops either of two "ebonite" cylinders, one containing the bolometer, and the other the ordinary reticule and eye-piece. The bolometer used in the measurements for these maps exposes to the spectrum a single vertical strip of platinum, $\frac{1}{8}^{mm}$ wide, covered with lampblack, and placed accurately in the axis of the ebonite cylinder by reversal under a compound microscope. The eye-piece also has its cross-wires centered in the second cylinder, and serves to examine optically the place which will be occupied by the bolometer strips when the bolometer cylinder is in the y's. The optical axis of the mirror, M, exactly bisects the angle between the direction of the arm, A′, and the central line of the track, so that a ray falling on the center of the mirror from the center of the instrument at P, after reflection falls upon the bolometer strips. C, C′ are counterpoises to offset the weight of the arms A, A′.

To adjust the apparatus for observation, the screws at D are loosened, the prism removed, and the arm A′ brought around in line with the long tube. The eye-piece being placed in the y's at B, the image of the distant slit is brought upon the central wire, when the reading of the divided circle should be 0° 00′ 00″, indicating a deviation of zero. The arm is then moved to one side as in the figure, until the mirror intercepts the rays from the prism, which has first been replaced upon its table and adjusted by the screws below. The prism is now carefully

set to minimum deviation (usually for the D_1 line) and is then automatically kept in minimum deviation for all other rays by the tail-piece and attachment at *D*. When the cross-wires of the eye-piece are set upon the *D* line the circle should indicate a deviation of 47° 41′ 15″. A bright and pure image of the spectrum about 6^{mm} wide and 640^{mm} long between the A and *H* lines is now formed in the principal focus of M near the prism, and the bolometer case being substituted for the eye-piece, the carriage is slid along the track until the central strip, placed vertically and parallel to the Frauenhofer lines, comes exactly into focus. The heat of the solar rays in any part of the spectrum may now be measured by the bolometer (the galvanometer giving a marked deflection as it passes over the leading Frauenhofer lines), and the deviation for that part is exactly indicated by the divided circle.

The galvanometer used in connection with the bolometer is a Thomson reflecting astatic galvanometer of about 20 ohms resistance, constructed especially for the purpose by Elliot Bros. of London. It is placed upon a pier entirely disconnected from the building. The scale is cylindrical, with divisions 1^{mm} apart on a transparent surface, and is placed 1 meter from the galvanometer mirror. Since the whole deflection ordinarily employed does not exceed 5°, as a rule the reading of the galvanometer requires no reduction for our present purpose. A resistance box forming the Wheatstone's bridge, and other electrical adjuncts of the bolometer are on the right of the galvanometer pier. The rheostat is in a convenient position near the scale, and the battery galvanometer for measuring and regulating the strength of the current used, is on a pier in another part of the room.

In conducting the measurements for mapping the spectrum, one observer is usually at the spectro-bolometer to set the circle to the deviation required, to see that the light from the Siderostat falls properly upon the prism, and to admit the sunlight at a given signal by means of cords attached to a sliding cover in front of the slit where the sun's rays first enter the room. Another observer, placed at the galvanometer, reads the corresponding indications of the instrument, and a third enters them in form in a book prepared for the purpose, and gives the signal for exposure. As all these observations are carried on in a partially darkened room, a fourth person is usually stationed without to wind the siderostat clock, and to give notice of any passing clouds to those within the building.

Example of the mode of observation.

As an example of the first class of measures, let us consider the observations made with the Hilger Prism on June 22, 1882. The high sun observation was made at $0^h\ 15^m$. The sun's zenith distance at this time was 17° 10′; the air mass* was 1·047 times the mass overhead; the height of the barometer corresponding to the air mass overhead was 7·39 decimeters, consequently the air mass for a zenith distance of 17° 10′ was $7{\cdot}39 \times 1{\cdot}047 = 7{\cdot}74$ decimeters.

The sun's zenith distance at $6^h\ 25^m$ (the time of the second observation,† was 79° 8′); the height of the barometer was the same as at noon, and the air mass by the same formula was 5·18 times that overhead, or $7{\cdot}39 \times 5{\cdot}18 = 38{\cdot}27$ decimeters, so that the mass of air traversed in the second observation exceeded that in the first by an amount capable of supporting 30·53 decimeters of mercury.

The galvanometer deflection obtained in the part of the spectrum whose deviation is 44° 30′ (a part which is near the extreme lower limit of the present observations, far below the visible red) was at noon 17, and in the afternoon 11. In the violet, where the deviation is 50° 00′, the corresponding deflections were 4·5 and 0·39. Let us take these two feeble extreme rays as types with which to illustrate our process. Considering first the infra-red ray we have, deflection at noon $= d_1 = 17$, deflection in afternoon $= d_2 = 11$, difference in mass of air traversed $= M_2\beta_2 - M_1\beta_1 = 30{\cdot}53$ decimeters, which, by its absorption, has produced the difference in the deflections. t representing the amount of energy transmitted by a layer of air equivalent to 1 decimeter of mercury, we find from the formula

$$t = (M_2\beta_2 - M_1\beta_1)\sqrt{\frac{d_2}{d_1}}$$

$t = {\cdot}986$; that is, a mass of air capable of supporting 1 decimeter of mercury in the barometer, transmits 98·6 per cent of the energy of this particular kind of ray. This quantity t we call the coefficient of transmission of the ray.

Knowing now the amount of energy transmitted by one such layer of air, we can find the amount transmitted by the 7·74 layers which intervened between the observer and the sun at noon, namely ${\cdot}986^{7{\cdot}74} = {\cdot}895$. Only 89·5 per cent, therefore, of the original unknown heat of the ray, which we will

* Computed from the formula $M = \dfrac{0{\cdot}0174 \text{ Tabular Refraction}}{\text{cos. app. altitude.}}$

† In general it is not advisable to make observations at so great a zenith distance as this.

represent by E, reached the observer at noon, producing a deflection of 17, or ·895 E = 17, giving

$$E = \frac{17}{\cdot 895} = 19\cdot 0$$

That is, had our instrument been placed outside the atmosphere at that time, it would have indicated a deflection of 19 instead of 17.

By a similar process we find that the coefficient of transmission for the violet ray is ·923, from which we see that the ultra-red ray is transmitted with greater facility than the violet. The amount of this violet radiation transmitted by the whole depth of atmosphere at noon was ·538, from which its energy outside the atmosphere was $\frac{4\cdot 5}{\cdot 538} = 8\cdot 4$.

The table below gives the coefficients of transmission, etc., for these and other points in the spectrum where measurements were taken on this day. The first column gives the deviation of the observed ray in the spectrum of the prism used, the second and third columns the deflections obtained with the galvanometer at noon and in the afternoon, respectively, the fourth column the coefficient of transmission (for an atmosphere supporting one decimeter of mercury), the fifth the transmission of the whole depth of atmosphere at noon, obtained by raising the coefficient of transmission to the 7·74 power, and the last the computed energy outside the atmosphere expressed in galvanometer deflections.

TABLE VIII.

Deviation.	d_1	d_2	t	$t^{M,\beta,}$	E
53° 00′	0·02	0·00			
52 00	0·21	0·00			
51 00	0·96	0·09	·925	·549	1·8
50 00	4·5	0·39	·923	·538	8·4
49 30	7·3	----	----	----	----
49 00	13·	3·0	·953	·689	18·9
48 00	43·	12·5	·960	·731	58·8
47 30	72·	38·	·979	·850	84·7
46 45	158·	109·	·988	·910	173·7
46 12	209·	134·	·986	·894	233·8
45 53	175·	107·	·984	·883	198·3
45 28	122·	79·	·986	·895	136·2
44 30	17·	11·	·986	·895	19·0

Similar reductions have been made for each day's observation the result from each being confirmatory of the statement here (see column $t^{M,\beta,}$) that the atmospheric absorption *diminishes* continuously as the wave-length increases (save for the interruptions already cited) to the extremity of our charts.

The graphic representation of this and other extra telluric curves of energy will be given in a later memoir, in such a

form as to show from the mean of a year's observations, the percentage of absorption suffered by each ray in the entire spectrum, visible and invisible.

The reader who may desire still fuller details as to the apparatus, the original observations and their treatment, is referred to the forthcoming official publication already mentioned. In the later memoir will be found a description of the method used for determining the wave-lengths corresponding to measured deviations, and the formulæ for deducing from the prismatic spectrum, the distribution of the energy and the extent of the spectrum on the normal scale.

SUMMARY.

As one result of this present research, the chart of the prismatic spectrum as observed at Allegheny with the bolometer is now presented (Plate III). The abscissæ are proportional to deviations and the ordinates to measured energies. The second chart now given, (Plate IV), represents the normal spectrum as deduced from the prismatic, as it has been thought advisable to present it here for the reader's convenience, in advance of a description of the means used for making it. The abscissæ on this are proportional to actually measured wave-lengths, and the ordinates to measured energies. In both charts, the area between ordinates corresponding to like wave-lengths is the same, and hence the total areas are the same. Their very dissimilar contour is due to the prismatic distortion.

Faint indications of solar energy below the lowest point here shown, have been found, and these, with some considerations as to the nature of the new absorption bands, may be given hereafter, together with tables (already prepared) of the absorptive action of the *solar* atmosphere for each spectral ray. These will, it is hoped, give with a satisfactory approximation the distribution of the energy, before any absorption whatever; at the source, that is, of the energy, in the photosphere itself.

The extent of the newly observed region may be most clearly seen by reference to the map of the normal or diffraction spectrum. (Plate IV.) Previous maps end at or near wave-length $1^{\mu}\cdot 2$. Beyond this point (with the exception of the single band near wave-length $1^{\mu}\cdot 4$) every line, and every ordinate representing heat, is believed to be new. The extent of the region here newly mapped, is then considerably larger, on the normal scale, than the whole of that (both visible and invisible) previously known.

We observe that the prismatic spectrum is enormously expanded at the violet end. To carry this on the prismatic

scale to wave-length $0^{\mu}.3$ would extend it far beyond the limits of our chart. *All* the actual energy in the entire ultra-violet part is, however, insignificant—how insignificant can best be seen by reference to the normal chart, where the minute area beyond wave-length $0^{\mu}.4$ represents the *whole* ultra-violet energy.

We are accustomed to speak of the ultra-violet or infra-red regions without reflecting on the enormous difference between their actual importance. The reader will be able to see by a simple inspection of the normal chart and a comparison of the little area above wave-length $0^{\mu}.3$, and the great area below wave-length 0·7, that the latter is nearly a hundred times as great as the former. Yet the former, owing to the prismatic expansion, and to the selective absorption by the feeble rays of this region of certain salts of silver, with which it can be photographed (while the far greater luminous energy below makes little impression on these salts), has occupied more attention than the latter. When we observe here how the infra-red region is compressed by the prism, we can understand how its extent has been under-estimated. Its real extent is so vast that we should accustom ourselves to consider "in the infra-red region" as a wholly vague term, needing to be supplemented with a description of the particular part of the infra-red referred to.

It may be well to epitomize the principal results of all these researches as far as they have been here given. In general they emphasize and extend our first conclusions.

1st. In measures now made for the first time on approximately homogeneous rays in the diffraction spectrum, we find that the maximum energy is above the red and is placed in fact near the yellow. The place of this maximum point varies with the sun's altitude, ranging from a wave-length of nearly $0^{\mu}.55$ on a clear day and with a high sun, to a wave-length of $0^{\mu}.65$, or even more before sunset. On the normal scale then, the position of the maximum of heat in the spectrum does not vary widely from that of the maximum of light. It is shown later how similar results are deducible from the prismatic spectrum.

2d. By comparing the ordinates for high and low sun in different parts of the spectrum, we see that they grow unequally, indicating an enormous systematic absorption, increasing toward the ultra-violet, and diminishing toward the infra-red, and these ordinates not only indicate its character but give its amount. In contradiction to the statement of many investigators and of present opinion on the point, we find that (according to these measures) the absorption grows on the whole less and less, as we go down below the red, to a point

near wave-length $2^{\mu}\cdot 8$. By this it is not meant to deny the existence of regions of very great local absorption in the lower spectrum. These same observations do in fact point out new regions of such local absorption. But excepting these they warrant us in saying that, broadly speaking, the absorption through the whole spectrum, visible and invisible, appears to follow one simple law, and to decrease where the wave-length increases; so that not only is the ultra-violet more absorbed than blue, blue than yellow, and yellow than red, but that red is more absorbed than the infra-red, and each degree of infra-red is more so than the next one below it.

3d. By the use of the ordinary logarithmic formula, here employed in its legitimate application to homogeneous waves, we can pass from the curve inside to that outside the atmosphere. In other words, we can virtually transport our observing station to a point wholly above the air, and determine the distribution of the sun's heat before this unequal absorbent action of our atmosphere has affected it. We need only embody the results for selective absorption given by our tables in a simple graphic construction (like that here shown in connection with the preliminary investigation), to see that the point of maximum heat *outside* our atmosphere lies near wave-lengths 0·50 to 0·55; or, as we are entitled to say, that the hottest portion of the spectrum outside the atmosphere will be found rather in the green than as here near the yellow.

It is probable, from our measurements, that the sun would appear of a decidedly bluish tint to the naked eye placed without our air.

This atmosphere which we are so accustomed to regard as colorless, has then, in fact, played a part analogous to that of a yellowish or reddish glass whose impure color is not a monochromatic yellow or red, but a compound of all spectral tints in unaccustomed proportions. Had we in all our lives had no light but from an electric light, seen through such a reddish glass shade, we should probably have believed this reddishness to be the "natural" or proper color of the naked carbons, and moreover that it represented "the sum of all radiations." It would apparently answer in an individual brought up in ignorance of any other light, to our common notion of *whiteness*, so that even though it really possessed color, the medium would (previous to investigation) be deemed colorless. In the same way common opinion regards our air as colorless, yet it cannot be so, but must necessarily (according to these observations), be considerably colored.

As we have been accustomed to regard it as colorless, however, it is clear that were it removed we should, in seeing the sun's true appearance for the first time, regard the sun itself as colored.

Our white light, then, is *not* the sum of all radiations, but only of a part, even of the visible ones.

4th. We can, by measuring the area of the curve outside our atmosphere and comparing it with the area of the curve within, obtain by a method never before pursued, which is in close accord with theory, a value for the Solar Constant.

Previous observations have found from 1·7 cal., in the time of Pouillet, to 2·5 cal. in that of Violle, with a tendency to increase. The value here given from our preliminary investigation is 2·84 cal. The last figure is of little weight and the exactness of that in the first decimal place is probably open to doubt. The conclusion which we are entitled to draw from these investigations in the stage here presented, is that the Solar Constant is in reality greater than has been heretofore supposed, and that it is probable that it is not very greatly inferior to 3 calories. This important point will be discussed fully in connection with the Mt. Whitney observations, with which the complete graphical constructions elucidatory of our present tables will be given.

5th. These observations show heat in extreme ultra violet rays, and the change of temperature (hitherto unobserved), in the Frauenhofer lines. They lend increased probability to the belief that *all* the energy in any ray can be exhibited as heat, if there be a proper medium to receive this energy. Their evidence, so far as it goes, then, favors the conception of one solar energy which is interpreted in terms of heat, or of light, or of chemical action, according to the medium by means of which we choose to observe it.

6th. The *ratio* of luminous to dark heat has evidently been wholly changed by the selective absorption. The ratio at the sea-level may be found with close approximation by measuring the two areas, (1st) above the point where we assume the luminous spectrum to end, and (2d) below it. This point each one may define differently, for the extent of the luminous spectrum depends much upon our precautions for observing it. If we assume it to end near B, then three-quarters of the energy must be termed invisible; if at the actual visual extremity (far below A), then less than half. To fix our ideas, let us suppose it to terminate at Frauenhofer's A. We then find

luminous and ultra-violet energy (within the smooth curve)	0·368
infra-red energy	0·632
	1·000

The ratio of the invisible (infra-red), to the whole then is 0·632, and there is reason to believe this value rather too small than too large. If, however, we deduct the space occupied by the gaps in the lower spectrum the ratio becomes 0·562. The

infra-red energy at sea-level may be roughly taken, as thus defined, at three-fifths the whole. At the same time the ratio of luminous to obscure energy without our atmosphere is, we repeat, far greater than within it.

We conclude (among other consequences of our observations) that since the heat in the shorter wave-lengths (corresponding in a general sense to high solar temperature) was thus relatively greater before absorption, we are obliged to increase our usual estimates, not only of the amount of heat the sun sends us, but (and very greatly) of the effective *temperature* of the solar surface.

The relatively small amount of energy, corresponding to great wave-lengths in the infra-red, is due not so much to absorption as to the fact that there is no considerable solar energy existing there at all. The relatively great amount of energy in the luminous part of the spectrum exists there, not on account of a feeble absorption, but *in spite* of a strong absorption, and the original solar energy here was even much more considerable than what we see.

It is probable, however, that the solar spectrum before absorption, though originally weak below the red, *yet extended very much farther into the infra-red than our charts indicate.* We may even regard it as probable that some agent of the atmosphere acts as an almost complete barrier to the entrance or departure of rays, below the point charted.

It should be understood that these researches have here a practical bearing of great consequence. The temperature of this planet, and with it the existence, not only of the human race, but of all organized life on the globe, appears, in the light of the conclusions reached by the Mt. Whitney expedition, to depend far less on the direct solar heat, than on the hitherto too little regarded quality of *selective* absorption in our atmosphere, which we are now studying.

The discussion of these and other points is reserved for a subsequent memoir. Among these will be the fuller consideration of the place of the principal absorption of water vapor, a consideration which it will be advantageous to present in another connection. It is to be remembered that all the values here given are presented as approximate and not as final ones.

In presenting these researches, on the part of the Allegheny Observatory, I should state that the considerable especial expenditures they have involved have been met by the generosity of a friend of that institution, whose aid, which alone made them possible, I would gratefully acknowledge.

In conclusion I desire to say that I have been aided throughout them by Messrs. F. W. Very and J. W. Keeler of this Observatory, with an efficiency and interest in their prosecution without which they could hardly have taken their present form.

Allegheny Observatory, Allegheny, Penn., Dec. 30, 1882.

ART. XIX.—*New locality of the Green Turquois known as Chalchuite, and on the Identity of Turquois with the Callais or Callaina of Pliny;* by WILLIAM P. BLAKE.

IN this Journal,* March, 1858, I directed attention to the occurrence in New Mexico of a green turquois highly prized as a gem by the aborigines and known as "*Chal-che-we-te.*" The completion of the railway along the valley of the Rio Grande has made the Cerillos Mountains, in which the gem occurs, much more accessible than it was, and the ancient mine has been re-opened and worked to some extent by Eastern capitalists, as made known by Professor Silliman.† The stone is in consequence more abundant than before, and at Wallace Station on the railway very good specimens can frequently be obtained of the Pueblo Indians.

I have recently visited another locality where chalchuite occurs and was mined by the ancients. This is in Cochise County, Arizona, about twenty miles from Tombstone, in an outlying ridge or spur of the Dragoon Mountains and not far from the stronghold of the Apache chief, Cochise, so long the terror of that region. This elevation is now known as the "Turquois Mountain," and as there are several deposits of argentiferous ores near it, a mining district has been formed called the "Turquois District."

At the turquois locality there are two or more ancient excavations upon the south face of the mountain, and large piles of waste or debris thrown out are overgrown with century plants, yuccas and Cactaceæ. It has not been worked for a long time and probably never by the Apaches. The excavations are not as extensive as at Los Cerillos, and it is more difficult to find specimens of the mineral. It is evidently much less abundant than at the New Mexican locality. Enough of the gem was obtained, however, by searching in the waste heaps, to show that it is identical in its appearance with the New Mexican chalchuite. The rock is also similar and the chalchuite occurs in seams and veinlets rarely more than an eighth or a quarter of an inch in thickness.

The color is light apple-green and pea-green, precisely that of the New Mexican stone, as generally seen. There is in some fragments a faint shade of blue as at Los Cerillos, but the true normal color appears to be green rather than blue.

The specific gravity I find to be, of two different fragments, 2·710 and 2·828. The first was slightly porous and earthy and the second dense, hard and homogeneous. These results are

* The Chalchihuitl of the ancient Mexicans, this Journal, II, xxv, 227.
† Ibid., III, xxii, 67, July, 1881.

higher than I obtained with the specimens from the surface at the New Mexican locality, viz: 2·426 to 2·651. Two determinations recently made gave 2·500 as the specific gravity of two partly cut stones from the old Cerillos locality.

This stone is peculiarly interesting archæologically. I have shown, in my former paper, that it was in general use and high esteem among the Aztecs and Moctezumas, before the advent of the Spaniards, and that the Pueblos and Navajoes still value it highly. It is evident that the stone wàs known to all the leading tribes inhabiting the plateau region of Mexico, including the northern portion now known as Arizona and New Mexico. Of this there is much confirmatory evidence, obtained since my first communication. The reopening of the old mine revealed many implements of the stone age, and showed workings of much greater extent than even the enormous surface excavations indicated. The early explorers and historians of New Spain chronicle the fact that the inhabitants of Cibola had an abundance of turquoises. We also know that the chalchuite was worked with considerable skill by ancient lapidaries. A few years ago a remarkable specimen of neatly executed mosaic work in chalchuite was dug up from the ruins near Casa Grande on the Gila. A mask from Mexico preserved in the British Museum appears to be overlaid with small tablets of the same green gem. The stone thus appears to have been used for incrusting and overlaying very much as it was in ancient Persia. Its opacity, hardness and the tabular form in which it is obtained, fit it peculiarly for this use. The descriptions by Pliny of the *Callais* or *Callaina* (*Καλλαϊνὸς λίθος*) apply well to a stone like the chalchuite. According to C. W. King* in his admirable work on gems, *callaina* probably was the original reading in the chapter of Pliny treating of callais, and is a name derived from a peculiar green dye, the *callaicum.* Pliny describes the color of the callais or callaina as pale yellow, mixed with green, and again that the best have the color of the emerald. . . "No gem is more improved by setting in gold, and gold itself is better set off by no gem. The better kind lose their color by wetting with oil, grease or wine, but the inferior retain it more permanently." But Mr. King while noting the fact that the callais of Pliny is now universally understood by modern mineralogists to have represented our turquois, thinks that the identification is not borne out by the description which Pliny gives. It seems to him to indicate a *transparent* rather than an opaque stone, an inferior peridot, perhaps. Pliny's statement that the stone is found of remarkable size, but full of holes and dross (*fistulosa*), is considered as repugnant to the idea of an opaque solid body like the modern turquois.

* C. W. King. The Natural History, Ancient and Modern, of Precious Stones and Gems, p. 136.

Such objections vanish before the specimens of chalchuite as they come from the mine. Large masses do not occur without earthy impregnations and mixtures of a yellow color. The mode of origin and the accretion of more or less rounded semi-globular crusts in the cracks of the rock often leave spaces in a fistulous form, and these are generally filled by earthy deposits, colored by iron oxide. In the selection of masses for jewels such imperfections are cut away and of course do not appear in the turquois of commerce.

That the stone of which Pliny treats is not a transparent gem seems to be clearly shown by the statement of the effect of oil or grease upon it. He evidently is describing an absorbent stone, a porous and consequently opaque mass. It is an interesting fact that the Pueblo Indians at this day resort to the expedient of soaking the chalchuite in tallow or grease to heighten the color and to make the tint of the larger specimens more uniform. The grease is taken up by the more porous and softer parts of the stone, while the harder portions of a deeper tint do not absorb it. Ben Mansur, in describing the turquois, also refers to the improvement of the color of some sorts of the stone by steeping in oil. Damour* refers the green-colored hydrous phosphate of alumina ornaments, found in a Celtic grave, to the callais of Pliny, especially in view of the green color. The mineral is evidently a somewhat altered green turquois and is not specifically different, but is well entitled to the name callainite, the modified form of Pliny's name proposed by Professor Dana.† The name turquois is certainly unsatisfactory for the species. Callais or callaina and also *chalchuite*, not only have precedence in time, but are distinctive and better in form, and with the modification noted are in accord with the terminology of the nomenclature of the science. Moreover they are not misleading as turquois (Turkish stone) is in regard to the source of the gem. Although some of the mineral may have been found in Turkey, Persia has been the chief locality. This is fully recognized by Buffon,‡ and he cites from various authorities particulars regarding the localities in Persia, at Nichabour and at Firusku in the province of Erak. One of these authors§ says that the turquoises were there called "*firuses*," and King mentions *Firuzegi* as the name of Persian turquois. Brongniart, ii, 225, quoting from Chardin, says the turquois is found in a mountain named "*Phirous*," between Hircania and Parthide. Again the name turquois is applied to the blue fossil bone or ivory, called also the Occidental turquois and odontolite, of which large quantities were formerly, and are still, used in jewelry.

* Compt. Rendus, lix, 936.

† Dana's Mineralogy, 5 edit., p. 572.

‡ Buffon, Histoire naturelle des Mineraux, 1790, viii, 51.

§ Adam Olearius; Voyage, &c., Paris, 1656, p. i, 461.

The fact that the beautiful green of chalchuite is the normal color of the gem, and that among the ancients, and even so recently as the last century, the stones of a green tint were the most prized, should lead to a higher appreciation of this gem and to its more extended use in jewelry and choice mosaics. Mr. C. W. King, in the work already cited, says that the very rare antique works in turquois are in the green kind, notably the head of Tiberius at Florence in a stone as large as a walnut, and other half relief works in green turquois in the Marlborough collection. The chalchuite is well adapted to cameo or intaglio work, and the color is finer by candle light than by sun light and the blue tint is deeper.

In using the name *chalchuite* instead of the longer form "*chalchihuitl*," as in my former paper, I now follow Bernal Diaz, the historian of the conquest of Mexico, rather than Lockhart, the translator, for brevity and the accordance of chalchuite with the now generally accepted terminology of the names of mineral species. This name in all probability is older than Pliny's, and if not given the precedence of callainite, should at least have the second place in the synonymy of the species.

Mill Rock, New Haven, Conn., Jan. 6, 1883.

ART. XX.—*On portions of the Skeleton of a Whale from gravel on the line of the Canada Pacific Railway, near Smith's Falls, Ontario;** by J. W. DAWSON.

BONES of large whales are not of infrequent occurrence on the less elevated terraces of the Pleistocene period on the Lower St. Lawrence. I have seen them at several places in the neighborhood of Metis, on the lowest sea terrace, now elevated only a few feet above the level of the sea, and they are reported to have been found on the second terrace at an elevation of 60 to 70 feet. Mr. Richardson, late of the Geological Survey, informs me that he has seen them in several other places on the lower terraces. It has also been reported that bones of a whale were found on Mt. Camille, in rear of Metis, at a considerable elevation; but Mr. Richardson, who visited the locality, failed to verify the statement. The bones found on the lower, and therefore modern terraces, are usually in a good state of preservation, and have a very recent appearance. The above statements relate to remains of the larger whalebone whales.

* From the Canadian Naturalist; communicated in an advanced proof by the author.

Remains of the *Beluga*, or small white whale, were found by the late Dr. Zadock Thompson, author of the "Natural History of Vermont," in the marine clay in the township of Charlotte, Vermont, at an elevation of 150 feet above the sea. They were associated with shells of *Saxicava* and *Leda*. The species was supposed to be distinct from the *B. Catodon* Gray, and was named by Thompson *B. Vermontana*. I have found detached bones of *Beluga* in the Post-pliocene clays of Riviere du Loup, and considerable portions of a skeleton were found in the excavations for the Intercolonial Railway, on the south side of the Baie des Chaleurs, and were described by Gilpin in the Transactions of the Nova Scotia Institute of Natural Science.* Bones have also been found in the brick clays near Montreal, and a specimen was discovered several years ago in sand holding *Saxicava*, near Cornwall, Ontario. The last named specimen was studied by Mr. Billings, and its bones compared with those of the modern species in the McGill College Museum. On this evidence Mr. Billings concluded that it belonged to the modern species, and I believe extended this conclusion to Dr. Thompson's specimen; the distinctive characters of which, as stated by that naturalist, seem not to exceed the individual differences in modern specimens.

But though the *Beluga*, which now extends its excursions far up the St. Lawrence, and has even been captured in the vicinity of Montreal, occurs as far west as Cornwall; no remains of the larger whales have, so far as I am aware, been found so far inland, until the discovery of the specimens referred to in the present note. These were found, as I am informed by Archer Baker, Esq., General Superintendent of the Canada Pacific Railway, "in a ballast pit, at Welshe's, on the line of the C. P. Railway, three miles north of Smith's Falls, and thirty-one miles north of the St. Lawrence River, in the Township of Montague, County of Lanark. They occurred in gravel at a depth of 30 feet from the surface, and about 50 feet back from the original face of the pit."

Mr. Peterson, C. E., has been kind enough to obtain for me the elevation of the place where the remains were found, as indicated by the railway levels. It is 420 feet above the level of the St. Lawrence at Hochelaga, or as nearly as possible 440 feet above sea-level. It is interesting to observe that this corresponds exactly with the height of one of the sea terraces on the Montreal mountain, and is only 30 feet lower than the well-marked beach with sea shells above Côte des Néiges, on the west side of the mountain. The highest level at which Post-pliocene marine shells are known to occur on Montreal mountain is near the park-keeper's house, at an elevation of

* Volume ii, 1874.

about 520 feet. These marine deposits of Montreal are of the same geological period with the Cetacean remains in question, so that the animal to which these belonged may have sailed past the rocky islet, which then represented Montreal mountain, at an elevation of 400 feet above the lower levels of the city, and in a wide sea which then covered all the plain of the Lower St. Lawrence.

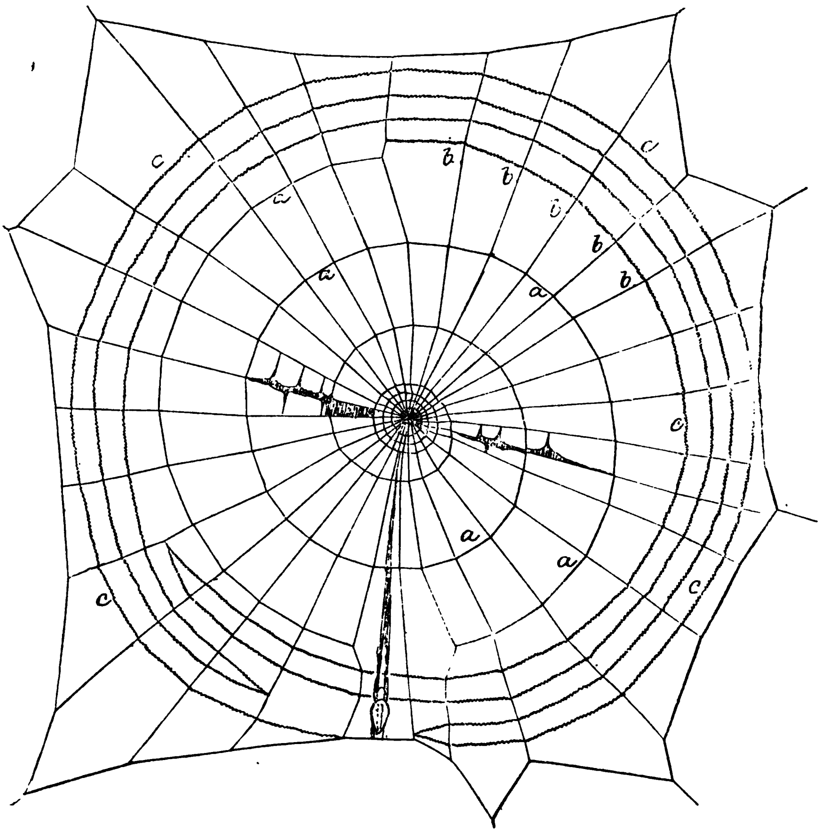
The deposit in which the remains occurred is no doubt the equivalent of the Saxicava sand and gravel, and was probably a beach or bank near the base of the Laurentian hills, forming the west side of a bay which then occupied the Silurian country between the Laurentian hills north of the Ottawa, and those extending southward toward the Thousand Islands, and which opened into a wide extension of the Gulf of St. Lawrence, reaching to the hills of Eastern Canada and New England, and westward, perhaps, to the Niagara escarpment at the head of Lake Ontario. Such a sea might well be frequented by whales in the summer season, and individuals might occasionally be stranded on shallows, or driven ashore by gales or by the pressure of floating ice.

The bones secured consist of two vertebræ and a fragment of another with a portion of a rib, and others are stated to have been found. They are in good preservation, but have become white and brittle through the loss of their animal matter. On comparison with such remains of whales as exist in the Peter Redpath Museum, and with the figures and descriptions of other species, I have little doubt that they belong to the Humpback whale, *Megaptera longimana* of Gray, *Balaena boops* of Fabricius, a species still common in the Gulf of St. Lawrence, and which extends its range some distance up the river, and is more disposed than most others of the large whales to haunt inland waters, and to approach the shores. I have seen it as far up the river as the mouth of the Saguenay, and there is reason to believe that occasionally it runs up much further. It is a species well known to the Gaspé whalers and often captured by them. Of course with so little material it is not possible to be absolutely certain as to the species, but I think it may safely be referred to that above named. The larger of the two vertebræ, a lumbar one, has the centrum eleven inches in transverse diameter, and is seven inches in length. The smaller, a dorsal, is ten inches in its greater diameter, and four in length. Through the kindness of Mr. Baker the specimens have been deposited in the Peter Redpath Museum of McGill University.

ART. XXI.—*The Cobwebs of Uloborus;* by J. H. EMERTON.

IN a recent article on the cribellum and calamistrum (Archiv für Naturgeschichte, 1882), P. Bertkau has cleared up the uncertainty about the structure of the cribellum by finding again the secreting glands at the ends of the fine tubes which

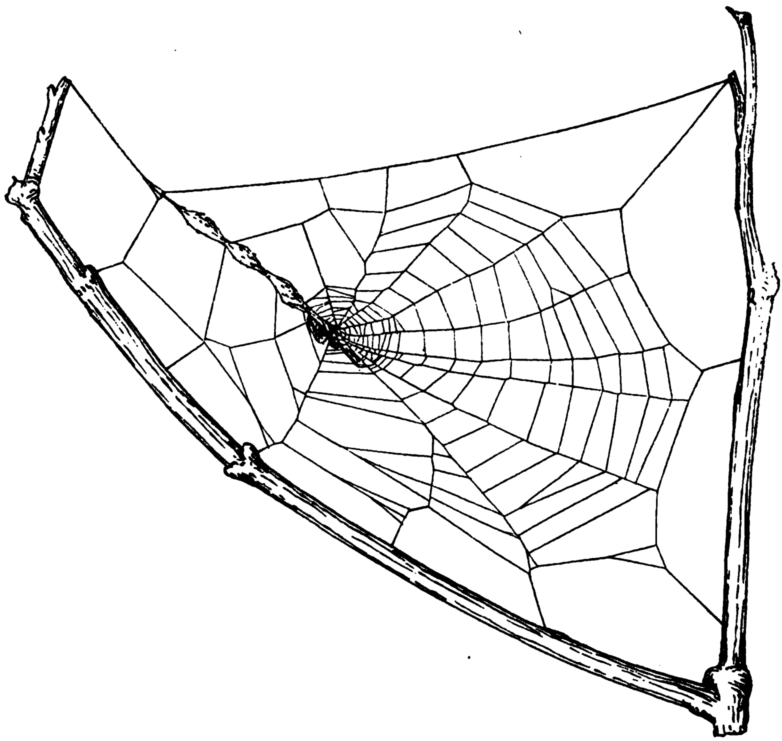
1.



have their outlets in this organ. Like Blackwall, Bertkau places together in one group all the spiders which are provided with the cribellum, instead of dividing them among several families according to their form and habits, as has been done by more recent writers. One of the principal reasons for this division has been the supposed resemblance of the webs of *Hyptiotes*, and especially of *Uloborus*, to those of the *Epeiridæ*,

and Bertkau appears to have had little opportunity to study the spinning habits of these two genera. He quotes the account by Wilder, of the making of the web of *Hyptiotes*, in Proc. Am. Ass. for Adv. of Science, vol. xxii, but is led into the mistake of supposing that the web of *Uloborus* is also a sector of a circle made in some such way as that of *Hyptiotes*. This is, however, by no means the case. The web of *Uloborus* is as round as that of most *Epeiridæ*, and is made in the same way by spinning a number of threads radiating from a center, cross-

2.

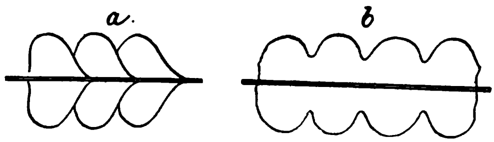


ing these with a loose spiral of the same kind of thread, and afterward beginning at the outside, crossing the rays again with closer spirals, gradually removing the first spiral of smooth thread, leaving only slight thickenings of the rays to show where it was attached. The principal difference between the webs is in the structure of the thread of the final spirals. In *Epeira* it is covered by a viscid liquid that collects on it in drops. In *Uloborus* it is covered by a band of fine threads drawn out by the calamistrum from the cribellum as described in *Hyptiotes*.

Fig. 1 represents an unfinished web of *Uloborus walckenærins* seen in France, showing the central part still occupied by the preliminary spirals, *a a*, while the outer part is covered with curled threads, and the smooth spirals cut away leaving thickened spots, *b b*, on the rays. In the finished web most of the spirals pass regularly around, but the outer ones are often more or less irregular as in *Epeira* webs, according to the shape of the space in which the web is made.

After laying her eggs, this spider, like many others, becomes careless about her web, and repairs it only enough to keep the cocoons in place, so that many imperfect and irregular webs are found at that season. I have seen such webs made by *Uloborus walckenærius*, and the only web I have seen of the American *Uloborus=Phillyra riparia* Hentz (fig. 2), is imperfect from the same cause, but is evidently the remains of a nearly round web, the rays' meeting somewhat nearer the upper than the lower edge.

3.



The thread of *Hyptiotes* and *Uloborus* has a strong smooth thread through the center. That of *Hyptiotes*, which I have examined fresh, has the finer part arranged in regular loops or scollops (fig. 3), *a*, *b*, in which the separate fibers cannot be distinguished. The thread of *Uloborus*, at least when old and dry, has the loops longer and less regular, and I have not been able to distinguish the separate fibers except at the edges of the band.

The close resemblance of the web of *Uloborus* to those of the *Epeiridæ* makes the classification of this genus still more difficult, for while its structure shows its close relationship to *Hyptiotes* and the other *Ciniflonidæ*, it is highly improbable that the habit of making such complicated webs of the same kind should have been acquired separately by *Uloborus* and by the *Epeiridæ*.

ART. XXII.—*Glacial Drift in the Upper Missouri River Region;* by CHARLES A. WHITE.

[Published in advance by permission of the Director of the U. S. Geological Survey.]

DURING my summer's work for the U. S. Geological Survey upon the Laramie Group, in the region of the lower portion of Yellowstone River in Montana, I was able to make some observations upon the Glacial Drift which are an interesting addition to our knowledge of its limits in the region west of the Mississippi River. Professor T. C. Chamberlin in his work for the Survey has traced this drift as far up the Missouri River as the town of Bismark, but the observations made by myself were much farther westward, and extended along the valley of the Missouri River for a distance of forty miles below the mouth of the Yellowstone, an equal distance above the mouth of that river, both in its own valley, and in that of the Missouri River. That is, my observations extended eighty miles along the Missouri, and forty miles up the Yellowstone. The drift material was seen mainly upon the crests and slopes of the bluffs which border those valleys, and consists of small bowlders and coarse gravel, without clays. It was found nowhere abundant, and over a large part of the space within which it was found, it is apparently absent.

The character of the rock composing the bowlders and gravel is essentially the same as that which I have seen in Northern Iowa and Southern Minnesota. The rock is mostly syenitic, some showing no lamination, some showing it indistinctly, and some being schistose; and the proportions of feldspar, quartz and hornblende, varying much in different specimens. Among these bowlders of Archæan rocks are frequent masses of cream-colored magnesian limestone containing fragments of fossils, which I regard as belonging to the Galena division of the Trenton limestone.

This glacial drift material is very different from the coarse drift gravel which is so abundant in the valley of the Yellowstone, and which has doubtless been derived from the mountain region about its sources. The latter is similar to that which is usually found in the valleys of rivers which have their rise in the Rocky Mountains.

ART. XXIII.—*Late Observations concerning the Molluscan Fauna, and the Geographical extent of the Laramie Group;* by C. A. WHITE.

THE observations that have been made concerning the faunal characteristics and geographical extent of the Laramie Group during the past year are of considerable importance. We now know the strata of that group to exist at numerous and extensive localities through more than twenty-four degrees of latitude; that is, from the State of Nuevo Leon in Mexico to the Valley of the Saskatchawan in British America.

Before giving a statement of the late observations referred to, it is necessary to an understanding of them that I should make a few explanatory remarks.

When speaking of the invertebrate fauna of the Laramie Group I refer to the fauna of a formation that is wholly different from that of any of the marine Cretaceous formations, with one of which some writers have confounded it; a fauna that as a whole and in details stands out more clearly distinct from the fauna of all the other geological formations of North America than any of the latter do from each other. The Laramie fauna contains no true marine types of any kind, but it does contain many brackish-water molluscan forms, and also the remains of many fresh-water and land mollusks. This fauna characterizes a great wide-spread geological group of strata in the most distinct and unequivocal manner, several of its molluscan species now being known to occur at localities more than a thousand miles apart.

It is cause for great regret that the admirable Text-book of Geology lately published by Professor Archibald Geikie should contain so erroneous a statement as it does of the molluscan fauna of the Laramie Group. I do not hesitate to assert that not one of the molluscan species mentioned in that statement were ever found in strata of the Laramie Group; the non-marine forms which he mentions being evidently those which were discovered by Mr. Meek in an estuary deposit of true Cretaceous age, at Coalville, Utah. Furthermore, not one of the numerous species which do characterize that group are anywhere mentioned in the book. With due recognition also of the value of the geological labors of Professor J. J. Stevenson, who has published several articles in this Journal, and in the Wheeler Reports, upon the Laramie Group, I am quite unable to reconcile his statements with my own extensive observations of that group and the study of its fossils. That any true Laramie strata ever alternate with those of the Fox Hills Group, or any other marine Cretaceous group; or that any true marine

fossils were ever collected from any strata of the Laramie Group, I cannot admit. I regard all such statements as the result of a misunderstanding of the stratigraphical geology of the region in which such observations are said to have been made.

The true molluscan fauna of the Laramie Group has been published mainly by the late Mr. F. B. Meek and myself. Most of Mr. Meek's species are figured in vol. ix. of the U. S. Geological Survey of the Territories; where they are referred to the Fort Union and Judith River groups respectively, which are now known to be only portions of the great Laramie Group. I have illustrated this fauna to a large extent in the Annual Report of the U. S. Geological Survey of the Territories for 1878,* and in the third Annual Report of the Director of the established United States Geological Survey. The latter work, now passing through the press, contains illustrations of all the known molluscan species of the Laramie Group.

In former publications I have referred to the fact that the strata of this group have been recognized from northern New Mexico to the British Possessions; and from the meridian of Great Salt Lake to that of Western Kansas and Nebraska. Besides the results of a full season's personal work upon the Laramie Group in Montana, I have, within the past year, received collections of its characteristic molluscan fossils from Professor Samuel Aughey, which he obtained in Western Nebraska; from Mr. Lawrence Bruner of the Entomological Commission; from the valley of the Saskatchawan, and from Mr. James T. Gardner from the State of Nuevo Leon in Mexico.

Those collected by Mr. Bruner were obtained in the valley of the South Saskatchawan, twenty miles above the mouth of the Bow River. They number only three species, but they are referrable to well-known Laramie forms. One of them is that which was described by Meek & Hayden from the Judith River group, under the name of *Ostrea glabra;* the second is *Corbicula* (*Leptesthes*) *fracta* Meek, the type-specimens of which came from the Bitter Creek series in Southern Wyoming; and the third is referred to *Goniobasis convexa* Meek and Hayden, the type specimens of which came from the Judith River Group.

The collection that has been received from Mexico was made at a point about seven and a half miles northwest of Lampazos in the State of Nuevo Leon, and numbers seven species, of which the following is a list:

* This volume is not yet published, but my extract from it, with 32 plates of illustrations, was published in 1880.

1. *Ostrea Wyomingensis* Meek.
2. *Anomia micronema* Meek.
3. *Modiola regularis* White?
4. *Corbula subundifera* White.
5. *Corbicula cytheriformis* Meek and Hayden?
6. *Odontobasis buccinoides* White.
7. *Melania Wyomingensis* Meek.

This Mexican collection, so far as it goes, is an almost exact duplication of the Laramie molluscan fauna of the Bitter Creek series as found at Rock Springs, Point of Rocks and Black Buttes, in Southern Wyoming, points which are more than a thousand miles north of the Mexican locality. The specimens represented by No. 1 are unmistakably like those from the original locality at Point of Rocks. Those of No. 2 are small examples such as are found at Rock Springs. The specimens of No. 3 are merely fragments, but they are presumably identical with *Modiola regularis* White, which occurs at Rock Springs. Those of No. 4 do not vary perceptibly from the type-specimens, which were found at Point of Rocks.

The *Corbicula* of No. 5 is closely like the form which I have referred to *C. cytheriformis*, found at Point of Rocks, but it is a little more angular upon its posterior slope. No. 6 cannot be separated from the type specimens of *Odontobasis buccinoides* that were found at Point of Rocks. The specimens of *Melania*, No. 7, present some variation from the type specimens that were found at Black Buttes, consisting mainly in their shorter form and the more pronounced character of the ornamentation. They are, however, regarded as of the same species, and their variation from the type specimens is no greater than the variation which they present among themselves. In short, the similarity of the Mexican and Wyoming shells is surprisingly close, considering their wide geographical separation.

These facts, together with others already published, show more and more clearly the integrity of the molluscan fauna of the great ancient intra-continental sea in which the Laramie Group was deposited, and its separateness from the faunæ of all other North American groups of strata.

ART. XXIV.—*The Sphingidæ of North America;* by A. R. GROTE, A.M.

THE readers of this Journal may be interested in a brief review of the present knowledge of our *Sphingidæ*, and the contrast it offers with that contained in Dr. Harris's article, published in this Journal, II, vol. xxxvi, p. 282, *et seq.* Dr. Harris's paper bears the title of "Descriptive Catalogue of the North American Insects belonging to the Linnæan genus Sphinx," and certain forms were included by him which now are placed in distinct families and are not considered in the present paper.

Dr. Harris divided the "Sphinges legitimæ" into three families of equal value, viz: *Sphingiadæ*, *Macroglossiadæ* and *Ægeriadæ.* The last is not considered a distinct family in the Latreillean sense. It varies by the larval habit and structure, no less than in peculiarities of the imago, from all known families of Lepidoptera, whereas the two former of Dr. Harris's "Families," possess only comparative distinctions of subordinate value, such as the absence or presence of the caudal tuftings, to authorize their separation. The larval structure is essentially similar, as all the details of the immature stages.

The issue of Dr. Harris's article was followed, in 1859, by an elaborate monographic paper from the pen of the late Dr. Clemens, in which the structure of the group was fully discussed, and the family term *Sphingidæ* used in the sense in which it is held in the present paper. In 1865 appeared "A Synonymical Catalogue of North American Sphingidæ," by the writer and the late Mr. Coleman T. Robinson, in which the synonymy of the species, which had been copied by Clemens from Walker's British Museum Lists, was again originally investigated, with the effect of establishing the synonymy since adopted in this country, and, so far as our fauna is concerned, abroad. Subsequently, the writer has revised the genera in various papers, and they are now brought into comparative accordance with the results reached more recently by Mr. Butler in his revision of the *Sphingidæ* from all parts of the world as far as known. In the present paper the writer endeavors to show the probable origin of the various Sphingid genera found in our territory, from a study of their structure and the representation of the family elsewhere.

In Dr. Harris's communication to the pages of this Journal, nine genera are adopted and thirty-four species, one being extra-limital. Under the term "North America," the territory north of Mexico and the West Indian Islands, is here, following the leading zoologists, intended. In my late "New Check

List," I have recorded thirty-four genera and ninety-one species from this territory.

Of the species enumerated by Dr. Harris, the names of six, *Quadricornis* (=*Amyntor* Hubn.), *Carolina* (=*Celeus* Hubn.), *Cinerea* (=*Chersis* Hubn.), *Sordida* (=*Eremitus* Hubn.), *Satellitia* (=*Pandorus* Hubn.), *Pelasgus* (=*Thysbe* Fabr.), were incorrectly given. Dr. Harris was unacquainted with Hubner's illustrations and works, and these corrections were found necessary by ourselves and other later students. Although the generic numbers have been subsequently increased, many of these names now used have become necessary from the discovery of new structural forms of the group within our territory, for instance, the genera *Euproserpinus* Grote and Robinson, and *Arctonotus* Boisd. Others have become necessary through the comparison of our *Sphingidæ* with those of other countries. For instance, so long as we only consider our own fauna, we might include our species of *Smerinthinæ* under one generic title simply as a matter of convenience. But when we find that our *Smerinthi* have varying affinities in other countries, and again contain certain exclusively American forms, we shall lose sight of their ultimate peculiarities of structure and their probable origin, by leaving them thrown loosely together under a common designation, which conceals valuable facts from public display.

Among the rich discoveries of the lamented elder Agassiz is the existence, in the southern portion of the Floridian peninsula, of a colony of animals belonging to the West Indian fauna. The collection of Floridian *Sphingidæ* in the Museum of Comparative Zoology has been examined by me, with the result of adding to our lists *Amphonyx Antæas*, *Dilophonota Alope* (=*Edwardsii* Butl.), etc., while collections from Indian River in Mr. B. Neumoegen's cabinet have added *Cautethia Grotei* Edw., from Florida and Cuba, to our fauna. As we entertain within our boundaries an Arctic colony on Mount Washington (my paper on which appeared in this Journal in 1875), we have a tropical settlement in Florida, the development of our knowledge of which is of the greatest zoological importance. At present the conclusions to which I have arrived from a study of the *Lepidoptera* may be stated here as follows: the stronger-winged and more migratory forms, *Sphingidæ* and *Noctuidæ*, are generally the same species as the West Indian; the weaker-winged forms, *Zygænidæ*, *Bombyces*, *Geometridæ*, show representative or distinct species. In the former case there is probably a constant infusion of new blood borne in on swift and nervous wings. In the latter, we may often have to consider that we are dealing with the descendants of forms established in the peninsula at the time of its separation

from existing islands in the Gulf of Mexico. Their wide wings break in the task of carrying their heavy bodies on the south winds, while their habit is sluggish and unambitious of long and steady flights. The length of "tongue" and custom of flower-feeding distinguishes the first of these two classes. The last contains species that taste but little honey and are shorter-lived in the perfect state. Indeed, some have the maxillæ quite short and weak and even aborted.

To return to the test of generic characters offered by our *Sphingidæ* on a comparison with allied forms elsewhere, I show that our *Smerinthi* belong to several distinct genera, based on the form of the wing, the nervulation, the peculiarities of the vestiture, shape of body, structure of palpi and antennæ. The genus *Smerinthus* of Latreille is based on the *Ocellatus* L. of Europe. We have one species from California, *Ophthalmicus* Bd., and its varietal form *Pallidulus* Edw., which is strictly congeneric with *Ocellatus*. Usually a case like this is used to show the greater resemblance of the western fauna with that of Europe as compared with our eastern animals. But I believe we should regard it as showing that both are descended from a Tertiary circumpolar fauna, and that the occasion for the differing distribution is due to the topography of the country. The migration which took place in the latter part of the Tertiary seems to be proved by the present location of such forms. The Rocky Mountains played an important part in the distribution of animals, dividing races, and limiting the range of species. In other papers I have attempted to show that the peopling of the continent came by way of the north and Behring's Straits during a former geological epoch. When we turn to our insects I have recently discovered, in New Mexican collections made by Professor Snow, a form, *Copimamestra Occidenta* Grote, living remote from the sea-boards, while representing the European *Copimamestra Brassicæ* in ornamentation, hairy eyes, tibial claw and thoracic structure. Such a discovery (just published by me) cannot be explained otherwise than that both were connected in former ages, and are remnants of a circumpolar fauna. The genus has not crossed the tropics. In the *Smerinthi* we have further the genus *Triptogon*, with two species, *Modesta* of Harris and *Occidentalis* of Edwards. An apparent larval modification of *Modesta* has been announced as a distinct species from Louisiana under the name of *Cablei*. But though the larva feeds on water plants and exhibits a difference in possessing dorsal tubercles or "horns," the drawing of the moth is so like our northern *Modesta*, which was unknown to the discoverer of *Cablei*, that there must be some mistake about it, and the species stands on a bad footing. But this genus is numerously represented by closely allied forms in Asia, as we

learn from Butler's treatise, and it is clear that ours must have originally come to us from the common ancestry of all the present species. For the American type of *Excæcatus*, I have retained Hubner's term *Paonias*. For the equally American type *Astylus*, I have proposed the necessarily new term *Calysymbolus*. Our remaining Smerinthoid form, *Juglandis*, differs more strongly than almost any structural form in the group from its allies. Confounded by Hubner with the rest of the gray *Smerinthi* under *Polyptichus*, it has been properly made the type of the genus *Cressonia* Grote and Robinson. The prejudice against the use of Hubner's genera will not find favor with those whose chief concern is the fact which lies beneath the term, and not the name used to show that it is apprehended.

We have, then, three proximate sources for our Sphingid fauna, which to-day consists of ninety-two or three species. That this number will not be greatly exceeded by future discoveries may be safely assumed. Although local species may await capture in New Mexico, Arizona or Southern California, the comparatively wide range and the muscular activity of these insects preclude the idea that this number will receive accessions as in the past. It has trebled since Harris's time, but the principal additions now seem likely to be from stragglers over our southern borders not yet noted in our lists. Again, in the genus *Hemaris* it may be that one or two names will drop from the list. Until all the facts are known, through a careful breeding of the species, it will not do to be hasty in drawing in any existing names in our comparatively small number of species.

The three elements, from as many sources, in our *Sphingid* fauna, are found first in descendants of a former circumpolar fauna; secondly, in accessions from the tropics, a movement from south to north being still in progress; thirdly, in those genera which have originated within our limits and are peculiarly North American in character. We may thus tabulate the genera of North American *Sphingidæ:*

1. *Descendants from a Circumpolar Fauna.*

Genus.	No. of Species.	Genus.	No. of Species.
Hemaris	14	*Triptogon*	2
Pogocolon	4	*Diludia*	3
Deilephila	2	*Sphinx*	15
Ampelophaga	1	*Hyloicus*	3
Smerinthus	1		—
Eusmerinthus	2	10 genera and	47 species.

2. *Accessions from the Tropics.*

Genera.	No. of Species.	Genera.	No. of Species.
Ællopos	2	*Chœrocampa*	2
Cautethia	1	*Amphonyx*	1
Amphion	1	*Phlegothontius*	4
Enyo	2	*Dilophonota*	6
Philampelus	4		—
Argeus	1	11 genera and	26 species.
Pachylia	2		

3. *Genera of North American origin peculiar to this Continent.*

Genera.	No. of Species.	Genera.	No. of Species.
Lepisesia	1	*Cressonia*	1
Euproserpinus	1	*Ceratomia*	3
Thyreus	1	*Daremma*	3
Deidamia	1	*Dolba*	1
Arctonotus	1	*Ellema*	3
Everyx	2	*Exedrium*	1
Paonias	1		—
Calasymbolus	2	14 genera and	20 species.

In these tables there is no separate account taken of the species of *Sphinx*. This genus cannot be satisfactorily split up, as I am sure that the different divisions proposed (e. g. *Lintneria*) have not sufficient or any real characters to sustain them. It is not as with *Smerinthus* where objective differences underlie all of the divisions. But many of the species fall evidently under either the second or third group. While *drupiferarum* is evidently allied to the European species, *Gordius* and allies are probably of southern extraction, and in *Elsa* and *Dollii* we have probably forms of American origin. The genus belongs to an older period of separation. The position of *Diludia* and *Daremma* is not assured, but I prefer the present to my first arrangement of the genera. We have neither *Macroglossa* nor *Acherontia;* the decisive element in our fauna does not come from the Old World.

But on the whole the tables are probably approximately accurate, sufficiently so as to draw attention to the class of facts which a study of this interesting group offers, and in presenting them, in connection with a resumé of our knowledge as to the number of kinds of North American *Sphingidæ*, the writer asks the indulgence of the reader. They have been the result of a long-continued study of this group of insects, and are put forth to invite the attention of entomologists to the recording of a class of facts which are of value in the large question of the distribution of life upon this globe, and which relieves entomology from the popular charge of being the cause of a frivolous waste of time upon insignificant objects. The writer also desired to trace subsequent progress in our knowledge of a subject which the late Dr. Harris had offered in this Journal nearly half a century ago.

ART. XXV.—"*Rotational Coefficients*" *of various Metals;* by EDWIN H. HALL.

THE experiments described below were made at the Laboratory of Harvard College during the summer of 1882, and most of the results obtained were given at the Montreal meeting of the American Association.

At the York meeting of the British Association, Sept., 1881, I gave a list of certain metals with an approximate value of the "rotational coefficient"* for each as determined by my experiments. This list was published in the report of the Association. Several of these metals had, however, been examined in an extremely inaccurate manner, as was stated at the time, and the numbers assigned them were marked as doubtful. Thus a part of the list ran:

Name of Metal.	Rotational Coefficient, Arbitrary Scale.
Zinc	+15· ?
Aluminium	—50· ?
Magnesium	—50· ?
Copper	—10· ?
Brass	— 1·3 ?
Lead	No effect discovered.

Repeating, still in a hasty and rough manner, but more carefully than before, the experiments with all these metals except magnesium, and using indeed the same pieces of metal as before, I found:

Name of Metal.	Rotational Coefficient.
Zinc	+10·5
Aluminium	—37·
Copper	— 6·5
Brass	— 1·4
Lead	No effect discovered.

It will be observed that the value obtained for brass, which is small, is but little changed, but those for zinc, aluminium and copper have each been reduced about 25 or 30 per cent. We may perhaps by analogy, without actual determination, write:

Magnesium .... —35

All these values may still be subject to errors of 10 or 20 per cent, but will nevertheless serve present purposes tolerably well, if substituted for those given in the list previously published. Such a list, though rough, may be compared with other

* Phil. Mag., Sept., 1881, p. 162.

lists in which the same metals are arranged relatively to various physical properties, and any analogies thus suggested may be tested farther by more accurate and detailed investigations. In fact, to go no farther than the above table itself, the fact that the small rotational coefficient in brass lies between the positive coefficient in zinc and the negative in copper suggests the advisability of a careful study of the transverse effect in alloys.

In the Phil. Mag. for Sept., 1881, I stated that the transverse current obtained with a nickel strip is much increased, other conditions remaining unchanged, by rise of temperature. It was a question of much interest whether the transverse current in the non-magnetic metals would prove to be affected in a similar manner. It might be found indeed that the transverse current would increase at the same rate as the electrical resistance, in which case it would appear that the transverse effect depends upon the rate of fall of electric potential along the strip of metal rather than upon the strength of the direct current.

Accordingly, from a sheet of No. 2 gold foil,* the thinnest foil used by dentists, a piece was cut in the form of a Greek cross. The extremity of each arm of this cross was soldered to a disk of brass. The four brass disks were screwed to a plate of hard rubber in such a manner as to extend the arms of the cross, which was then fastened to the rubber plate by means of melted resin run between. Wires soldered to the disks served for the connections.

The very considerable difficulty of soldering so thin a strip of gold and then fastening it upon the plate, has heretofore prevented my employing this method of makiug connections with that metal, screw clamps being used instead. The practical advantage of soldered connections is of course considerable, though not so great as might at first appear. Resin, although very brittle, was used as a cement, for the reason that within the limits of temperature to be employed it is more rigid than any other cement I could hit upon, and therefore less liable to allow the gold strip to become distorted or strained by the stress it is subjected to while carrying a current across a powerful magnetic field.

In order to control the temperature of the gold strip, it was placed in a narrow tank between the poles of the electro-magnet, and water was made to flow slowly through the tank, from bottom to top, during the experiment. The lowest temperature used was about 2° C., the highest about 30° C., as will be seen below.

Aug. 2 the following results were obtained in the order given:

* "Standard," R. S. Williams & Co.

Gold.

Temperature.	Numbers proportional to transverse effect.
30°·2 C.	1738
2°·2	1703
2°·6	1748
30°·0	1746

No attempt was made to determine the absolute magnitude of the rotational coefficient in this specimen of gold, so that the numbers given in the second column must not be used for comparison with numbers elsewhere given as proportional to the rotational coefficient in gold or other metals.

The magnetic field in these experiments had an intensity of about 1900 C. G. S. The primary current was not measured in absolute units. It was such as a Bunsen cell yields in a circuit of a few ohms resistance.

From the above table we get:

Temperature.		Numbers proportional to transverse effect.	
30°·2	30°·1	1738	1742
30°·0		1746	
2°·2	2°·4	1703	1726
2°·6		1748	

The mean of the numbers at low temperature is therefore less than the mean for the higher temperature by rather less than one per cent. The particularly small number 1703, which causes this result, was obtained from a rather bad series of observations, and is probably entitled to less weight than the others. In fact, though the numbers as they stand seem to indicate a decrease of about one per cent in the value of the transverse effect for a fall of about 30° C., I think it better to say that we have here detected no certain effect of fall of temperature.

It is evident from these experiments that if the value of the transverse effect in gold varies at all with change of temperature, it varies far less than the electrical conductivity. We must conclude, therefore, that this effect depends rather upon the magnitude of the current through the gold than upon the fall of potential per unit of length. This conclusion was long ago* reached, but doubt had been cast upon its correctness by the experiments upon nickel above-mentioned.

Turning again to the magnetic metals and taking a strip of thin iron, experiments were made similar to those with gold as above described. The results obtained, though by no means so accurate as those obtained with gold, show that in iron the rotational coefficient is very strongly affected by change of

* This Journal, Sept., 1880.

temperature, the effect being an increase of perhaps two-thirds of one per cent for a rise of 1° C. Possibly a comparison of the effect of change of temperature upon the magnetic permeability of iron, nickel and cobalt, with the effect of the same change upon the rotational coefficient, will be of value when both effects shall have been more fully studied.

Leaving the matter of effect of change of temperature and referring again to the article on nickel and cobalt (Phil. Mag., Sept., 1881), we see that the rotational coefficient in nickel decreases as we increase the strength of the magnetic field; i. e. the rotational *effect*, other things being equal, increases less rapidly than the intensity of the magnetic field.

Experiments were made for the purpose of determining whether a similar relation would hold in iron. The iron was tested in magnetic fields varying in intensity from about 1000 to about 7500 in absolute C. G. S. units. Judging from the behavior of the strip of nickel previously examined in this manner, the R. C. of that metal would be about 20 per cent greater in a field of intensity 1000 than in one of intensity 7500. For certain reasons I do not feel perfect confidence in the numerical results obtained with iron, and do not consider them worth publishing. To myself, however, they make it seem probable that the rotational coefficient in iron is *less* in a field of intensity 1000 than in a field of intensity 7500, and I expect to prove this when I am able to take up the matter again. Cobalt should of course be examined in the same way, nor must it be forgotten that it is by no means proved, as yet, that the non-magnetic metals will show a constant rotational coefficient when tested between wide limits of magnetic force.

The object of another experiment was to determine, if possible, whether any part of the rotational effect could be made permanent under favorable conditions. For this purpose a piece of clock spring was taken, tempered very hard, and then reduced by action of nitric acid to a thickness of about ·06$^{\mathrm{mm}}$. This piece of steel was firmly imbedded upon a plate of glass in a layer of cement made of melted beeswax and resin. This plate, with the usual electrical connections, and with a current flowing through it, was placed in the usual position between the poles of the electro-magnet; the magnet current was turned on, then off, and the plate removed from between the poles in order to avoid the action of the very considerable residual magnetism of the electro-magnet. A reading of the Thomson galvanometer in the transverse circuit was now made, then the plate was replaced between the poles and the current turned on again but in the opposite direction. The magnet current being again interrupted, the plate was again removed from the field and another reading of the Thomson galvanometer was made.

The two readings differed by several centimeters on the galvanometer scale. The experiment was repeated and always with a like result.

There was no room for doubt that the direction of the equipotential lines in the steel was permanently changed by the action of the magnet. This change was in the same direction as the temporary change produced by the magnet's action, and perhaps equal to 2 per cent of the temporary change.

This result was of course not unexpected. The hardened steel must have become permanently magnetized transversely, and this magnetization should produce an effect similar to that of temporary magnetization. The experiment is of interest, however, as indicating that the rotational effect is not due to the mere mechanical stress to which the metal is subjected in the magnetic field, for though no one has ever pointed out how any such stress could produce the effect observed, many have no doubt questioned whether it might not after all be due in some obscure way to such stress.

It may be stated incidentally that the transverse effect appears to be much greater in steel of blue temper than in soft iron, and again much greater in steel of very hard temper than in steel of blue temper. If we call the effect in soft iron 1, the effect in blue steel is perhaps 2, and that in very hard steel 4.

ART. XXVI.—*Recent Exploration of the volcanic Phenomena of the Hawaiian Islands;* by Captain C. E. DUTTON. (From a letter to J. D. Dana, dated Washington, D. C., Feb. 8, 1883.)

RETURNING from my long visit to the Hawaiian Islands, I feel that I owe it to you to make some return for the kind interest you took in my journey and for the valuable suggestions you made me prior to my departure. I therefore avail myself of a convenient opportunity to tell you briefly some of the matters which most particularly interested me.

After making such purchases as were thought necessary for my journey at Honolulu, I took the inter-island steamer for the southern part of Hawaii. I did not go to Hilo at first, as travelers generally do, for after making inquiry, I came to the conclusion that the southern part of the island would be a much more advantageous position from which to begin the study of Mauna Loa and Kilauea. The Hilo side of the island is very rainy. The field geologist quickly gets accustomed to every inconvenience and discomfort of travel except one, and that is mud; and the more he has to do with mud the more he hates it. The southern district of the island, Kau, is almost

always dry and the traveling good enough. I fitted out a pack-train with six packs, in regular Rocky Mountain style, and my first journey, of course, was to Kilauea. It is far pleasanter to approach the volcano from the Kau side than from the Hilo side, and the journey was full of interest. My first visit to Kilauea lasted ten days, during which I explored the great pit thoroughly and also the country round about. If I can rightly estimate the accounts of observers who saw Kilauea forty years or more ago, I should infer that the total amount of volcanic energy now manifested there has very considerably diminished. There is difficulty, however, in forming an estimate of how much allowance should be made for the enthusiasm and excited imaginations of travelers who for the first time, and generally the only time, have beheld this wonderful spectacle. The great inner pit, which was first described by Ellis in his Polynesian Researches, in 1823, and also by yourself, in 1841, has been completely filled up. The great outer cavity also has, I infer, become notably shallower, having been partially filled by innumerable overflows of lava. The inner cavity, which once held a burning lake, is now represented by two lakes, whose united surfaces have, I should judge, an extent which is but a small fraction of the surface of the old lake of forty or fifty years ago. These two lakes are both situated with their surfaces at levels higher than the mean level of the main floor of the pit. I infer too that they are much more languid and sluggish in their action than the lake which you saw.

The height of the walls surrounding the pit varies from 320 to 740 feet. There is abundant evidence that the floor of the pit sinks down more or less after every eruption within it, but presumably not to so great an extent as to compensate the building up of the floor after the successive out-pours of lava, so that, on the whole, the pit is probably growing shallower.

I watched, with the deepest interest, the action of the lava in the lakes. The most accessible one is now called the New Lake. It undergoes a series of regular changes within a period of about two hours. When we reach the brink of it we generally find it frozen over and quite black and still, except at the edges, where we perceive a rim of fire. We observe also at many places upon the edges a little sputtering and blowing out of lava and hear a dull simmering sound. At length a piece of the black lava upon the surface cracks, turns down its edge and sinks, disclosing a patch of livid fire. Soon after in some other part of the lake, at the edge, another piece breaks and goes down. This becomes more and more frequent until at last a hundred cracks suddenly shoot through the entire surface, and, with a grand commotion, numberless

fragments of the frozen surface plunge downward, leaving the whole one glowing mass of lava. For a few minutes the spectacle is very grand, but it does not last long. The surface quickly darkens and freezes over again, becoming black as before and in this condition it remains for an hour or two. The period between break-ups is not regular, being as short as forty minutes and as long as two hours and a quarter.

The explanation of the phenomenon is, I think, not difficult. When the lava first passes from the liquid to the solid condition, while its temperature is still near the melting point, but below it, its density is less than that of the lava below. As the crust thickens and the surface becomes cooler, its density becomes greater than that of the lava below, and its position then becomes unstable. A slight disturbance produces a rupture, and the sinking of one fragment is quickly followed by that of the others.

It has been the custom to speak of Kilauea as being situated upon the flanks of Mauna Loa and to regard it as a mere appendage of that mountain. But it presents itself to me as a distinct volcano having no more connection with Mauna Loa than Mauna Kea has. Into the discussion of this I cannot now enter.

From Kilauea I went to Mauna Loa. My first objective point was the source of the last great eruption of 1880–81. It is reached with difficulty on account of the roughness of the clinker fields, or *aa*, as it is termed in the islands. The vents are situated from twelve to eighteen hundred feet below the summit, upon the northeastern spur. Three distinct streams flowed from as many vents, one flowing northward to the base of Mauna Kea, a second flowing southward into Kau, and the third, and by far the largest, flowing first northward then deflecting eastward until it came within half a mile of Hilo. This latter stream was about fifty miles in length and varied in width from half a mile to two miles. The appearances presented at this point I shall describe at a future time. It may be sufficient to state here that a series of parallel fissures pointing from the summit toward the base of the mountain gave issue to the lavas. No cone was built, and there is no accumulation whatsoever of fragmental eruptive products.

I was deeply impressed with the colossal character of the eruptions of Mauna Loa. Of the eruptions which bear historic date that of 1855 appears to have been the grandest. It would have almost built Vesuvius. The accounts given to me by many eye witnesses of these eruptions recite observations which strike me as most extraordinary, though I cannot for a moment question the general truthfulness of these ac-

counts attested by so many intelligent and credible witnesses. The general version is that they break out suddenly and without warning, and that the lava spouts upward in enormous fountains to a great altitude, which the various observers estimate all the way from 500 to 1000 feet. How much of this may be attributed to incandescent steam and how much to optical illusion of one kind or another it is impossible to say. But I cannot doubt the general testimony that these vast lava fountains do spout upward to a very considerable height, and that the fires which are actually seen are mostly lavas. I think there is substantial evidence of this in the appearances presented at the sources of the great eruptions of 1855, '59 and '68. Dr. Coan visited the source of the eruption of 1855 while it was still active; and about three months before his death I had the privilege of inquiring of him very particularly about this matter, and his account substantiates the general testimony.

One of the most striking features of Mauna Loa is the almost total absence of cinder cones. There are a few small piles of fragmental material here and there, but they are mere apologies for cinder cones and are very aberrant in their modes of aggregation and in the character of component materials. Considering the portentous nature of these monstrous outbreaks, it is wonderful how little disturbance attends them. No earthquakes, no rending and shaking of the mountain nor roar of escaping vapors, no vast clouds of steam, but simply a huge river of fiery lava welling forth like water from a fountain and flowing swiftly on its course down the mountain side. So far as I have ever heard, this quiet character of the eruptions, the absence of fragmental products, and the insignificant amount of elastic force exerted by escaping vapors are without a parallel.

All of the great eruptions of Mauna Loa come from fissures which point from the summit of the mountain directly down its slopes.

I visited the great pit at the summit of Mauna Loa twice from two different lines of approach. It is very nearly equal in its horizontal extent to Kilauea, but it is much deeper, being about a thousand feet in depth, and is a much more impressive spectacle. It was absolutely still, without a trace of igneous action at the time of my visit. Before the last great eruption it was in a state of intense activity, spouting out lava in jets which attained a height of seven or eight hundred feet, and the igneous phenomena were, judging from all accounts, far more impressive than those of Kilauea. The glare of its fires was seen a few days before the last eruption; but it would seem that as soon as the last eruption began, the vents

at the summit immediately sealed up, being tapped, I presume, by the outbreaks which occurred at a considerably lower level.

The lavas of both Kilauea and Mauna Loa seem to me to be of an abnormal type. The analyses are not yet made and I can therefore give only their superficial character. They have the appearance of being extremely basic, decidedly more so than normal basalts. I cannot help thinking that they may be fairly relegated to what Judd describes as ultra basalts. Most of the lavas of Mauna Loa contain excessive quantities of olivine, many specimens being at least half composed of that mineral. The lavas of Kilauea, on the other hand, whether in the pit itself or in the country round about, seldom show much olivine. But the eruption of 1840, which belongs physically to the Kilauea group, is highly olivinitic, while the last eruption of Mauna Loa shows little or no olivine. I am led to suspect that the ultimate analyses of the two lavas, whether olivinitic or not, will show but little difference. In other words, I suspect that in some cases the olivine was crystallized in the lava before eruption, while in others it was not, the magma being very nearly identical in both cases.

I spent a great deal of time in the study of Mauna Kea. This volcano contrasts strongly in its aspect with Mauna Loa. Its lavas are apparently more nearly normal basalts and show a somewhat wider range of variety. The most striking difference in the two mountains is the absence of fragmental products upon Mauna Loa and their great abundance on Mauna Kea. The latter mountain is covered all over with magnificent cinder cones of large size and beautiful proportions, which are, by far, the most striking features of its mass. Many superb cinder cones are scattered thickly around its base and over its great flanks, and a large cluster of them forms its summit. The activity of Mauna Kea has probably been extinct for a very considerable period of time. When we first look upon its cinder cones in a perfect state of preservation, the first impression is in favor of great recency in its activity, but a more careful study of the surroundings leads to a modification of this view. Upon the windward side of the mountain the ravages of time are very apparent and quite extensive. Upon the leeward side they are far less extensive, but are by no means wanting. During the past few years my attention has frequently been called to the very great inequalities of effects produced upon the same mass by varying degrees of energy in the agencies of degradation. Nowhere does it come out more clearly than in these islands. The windward sides in most cases have been devastated to an astonishing degree, so much so that I sometimes shrink from the task of trying to convince anybody of the reality which I am sure of. But on the lee-

ward sides, which have undoubtedly been exposed for an equal period of time, the degradation is but a small fraction of what appears upon the windward sides.

The cause of the difference in the forms of Mauna Loa and Mauna Kea is very apparent; the former being built up entirely of fluent lavas, without fragmental products; and the lava streams being of great magnitude, the ejected material has diffused itself over a very wide extent of country and flowed many miles away from the principal focus of eruption. The mountain, therefore, is abnormally flat in its profile. In Mauna Kea, on the other hand, so large a proportion of the ejecta being in a fragmental form, they are piled up around the places where they were thrown out. The mass of Mauna Kea is many times smaller than that of Mauna Loa; but the top of its summit platform is only six or seven hundred feet lower than that of Mauna Loa, while the cinder cones upon the summit carry its apex about two hundred feet higher than the summit of Mauna Loa.

On all the slopes of Mauna Loa there is nowhere to be found anything like a ravine. Nor is there a single living stream, however small. And yet on all sides the precipitation is very great, but the water sinks as rapidly as it falls. The lava is highly vesicular and much broken, never compact except in bands here and there, at the bases of the larger flows. Every lava stream gives rise to long pipes or tunnels and there are literally thousands of them, some of which are several miles in length. In truth, these long caverns must form an appreciable portion of the entire volume of the mountain. Remembering also the very vesicular character of the lava, it seems plain that while the absolute density of the materials is very high, the specific gravity of the mass as a whole is by no means so.

It appears to be a general fact throughout the islands that erosion does not take hold of these volcanic piles to any appreciable extent during their activity, and after they become extinct a long period must still elapse before surface erosion other than chemical weathering can begin. The cutting of ravines is impossible without running water, and the water cannot collect in streams until the cracks and pores of the lava are silted up. Of course, this takes place more quickly upon the windward than upon the leeward sides. These facts are abundantly illustrated on every island in the group.

I also visited Hualalai, which has an altitude of about 8,600 feet. It seems to be intermediate as regards the character of its lavas and many of its eruptions between Mauna Kea and Mauna Loa; being more basic than the former, less so than the latter. It has many cinder cones upon it, especially at the

summit, some of which resemble those of Mauna Kea, while others have the abortive, abnormal and dwarfed character of the very few which occur upon Mauna Loa. This volcano it is well known has been active in the early part of the present century. From 1801 to 1811 there were three distinct eruptions, separated by intervals of a very few years, but all of them were small. One of them, as nearly as can be made out, must have occurred about the year 1801, the second in 1805, and the last in 1810 or 1811.

Kohala Mountain, at the north end of the island, is about 5400 feet in height, and its activity, no doubt, ceased at an earlier period than that of Mauna Kea. Its lavas are largely normal basalts, much of it approaching andesite in character. It appears to be notably less basic on the whole than the lavas of Mauna Kea. It has many cinder cones, some of them perfectly well preserved, others showing conspicuous traces of decay.

My visit to Maui, though briefer than that to Hawaii, was very interesting. The great volcano Haleakala is about 10,400 feet high. The great "crater" (so-called) at the summit possesses a grandeur and impressiveness which have not been overrated by travelers who have heretofore described it. The form of this summit depression is certainly most extraordinary and not easy to account for. It is impossible, however, to describe this mountain briefly, and I shall not here attempt to do so. It is wholly basaltic and in its general characteristics a pretty close imitation of Mauna Loa. The mountain piles which make up west Maui are much older. They are very much degraded by erosion and literally sawed to pieces by gorges and ravines two thousand to three thousand feet in depth, with precipitous walls. Some of the scenery in these gorges possesses a beauty and grandeur seldom equalled. It is highly peculiar, and so far as I know has its counterpart only in other islands of the Pacific. I found here some lavas which appear to be true andesites, though in the main, the rocks are of a mildly basaltic type.

I also went over the island of Oahu pretty thoroughly. It has many points of interest, of which, perhaps, the most notable are the studies of erosion which it presents. I may make the same remark regarding the island of Kauai. It has frequently been noted that the western islands of the group are the oldest and the antiquity diminishes from northwest to southeast. I consider the conclusion safe, however, only to this extent, that the eruptions in the western islands ceased at an earlier period, though it does not necessarily follow that they began any earlier.

There are abundant evidences of recent elevation in the

islands, the amount of which varies greatly. In a few portions there are marked traces of subsidence, though on the whole the elevating movement has greatly predominated. This subject is too complicated to be discussed here.

It would be impossible for me now to give much idea of the new facts I have learned. I have made no grand discoveries and of course I did not expect to. But I have picked up much knowledge of small details, the value of which no one but a geologist can appreciate; no nuggets but a good deal of fine gold. I think I understand much better than I ever did before the action and behavior of lavas, their modes of accumulation and their methods of flowing. To some extent, no doubt, these observations relate to matters peculiar to the islands, and it would not be safe to consider them typical; but I imagine that their utility will not be less on that account.

One of the most pleasing studies in these islands is the climatology. In truth, there are about as many climates as there are square leagues; yet all of them seem to be reducible to ordinary and well known laws, and when understood form some of the most beautiful examples of the operations of those laws which can well be imagined.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Isomorphism of Mass.*—The laws of isomorphism as enunciated by Mitscherlich in 1819 are as follows: 1st, two bodies are said to be isomorphous when, possessing the same crystalline form, they are capable of crystallizing together in the same crystal; and 2d, two isomorphous bodies possess an analogous chemical constitution. Klein has called attention to the fundamental modification of these laws required by the progress of science, and instances as isomorphous bodies forming exceptions to the above laws (1) the double fluorides of titanium with the double oxyfluorides of columbium and tungsten of Marignac; (2) the quadratic metatungstates and the monoclinic metatungstates of Scheibler, the members of both these groups being isomorphous among themselves, though varying in their water of crystallization; (3) certain silicotungstates of Marignac, the acid salts of barium and calcium being isomorphous with the rhombohedric form of the acid, and the monosodic salt with fourteen molecules of water, with the disodic salt containing eleven; (4) anhydrous sodium sulphate, Na_2SO_4, with sodium chromate, Na_2CrO_4, $(H_2O)_2$, as observed by Wyrouboff; (5) the double chlorides $(KCl)_3InCl_3(H_2O)_{1\frac{1}{2}}$ and $(KCl)_3TlCl_3(H_2O)_2$, observed by Fock; and (6) the borotungstates, noted by Klein himself. These are: a borotungstic acid $(WO_3)_9B_2O_3(H_2O)_2$, $(H_2O)_{22}$, with

the silicotungstic acid of Marignac $(WO_3)_{12}SiO_2(H_2O)_4, (H_2O)_{29}$, and also with the monosodic borotungstate $(WO_3)_9B_2O_3Na_2OH_2O, (H_2O)_{22}$; a barium borotungstate $(WO_3)_9B_2O_3(BaO)_2, (H_2O)_{18}$, with the barium metatungstate $(WO_3)_4BaO, (H_2O)_9$ of Scheibler; a diammonium borotungstate $(WO_3)_9B_2O_3(NH_4O)_2(H_2O)_2, (H_2O)_{19}$ with an ammonium metatungstate described by Marignac. The isomorphism in these cases is complete; so much so that, for example, a crystal of barium metatungstate will cause a supersaturated solution of di-barium borotungstate to crystallize at once. Accepting a suggestion made by Marignac some time ago, that two compounds containing a common element or group of elements constituting the greater part of them by weight, may be isomorphous even if they have not a similar atomic constitution, Klein formulates the laws of isomorphism thus: 1st. Two bodies are called isomorphous when they have the same crystalline form and are capable of crystallizing in all, or in very variable proportions in the same crystal. 2d. Two isomorphous bodies have either an analogous chemical composition (constitutional isomorphism), or are formed in great part of a group of elements which are common or have an analogous function (mass isomorphism). The exceptional cases above given are all included under the law of isomorphism of mass.—*Bull. Soc. Ch.*, II, xxxix, 10, Jan., 1883. G. F. B.

2. *On a case of Physical Isomerism.*—LELLMANN has observed a marked case of physical isomerism. Dibenzoyldiamidodibromdiphenyl, prepared by benzoylizing Fittig's diamidodibromdiphenyl, crystallizes from hot alcohol in fine colorless needles which fuse in capillary tubes at 195°. When the mass has become liquid, if the tube be suddenly removed from the bath and quickly cooled, the contents solidify to a transparent vitreous mass which, placed in a cold bath and gradually heated, fuses at 99°. If the heat be continued, the resulting liquid solidifies again between 125° and 130° to an opake crystalline mass, which again fuses at 195° as before. The changes are better observed by heating the substance as crystallized from alcohol on a watch glass over a flame and then cooling. The glassy mass is pulverized and placed in a fine tube, where its liquefaction is more readily observed on heating. It would appear that the sudden cooling from 195° to the ordinary temperature, causes it to assume another physical state; because if allowed to cool slowly no such change takes place.—*Ber. Berl. Chem. Ges.*, xv, 2835, Dec., 1882. G. F. B.

3. *On Nitrogen Selenide.*—VERNEUIL has examined the selenide of nitrogen discovered by Wöhler in 1859. The process of preparation used by the discoverer was to saturate selenium perchloride with ammonia gas. But the author finds that Fordos & Gelis's process for nitrogen sulphide gives better results. Ten grams of the perchloride are mixed with a few drops of carbon disulphide, and the paste thus made is suspended in a liter of CS_2 in which it is almost insoluble. Into this liquid a current of dry ammonia gas is passed. Flocks of ammonium chloride are precipitated and the liquid passes from a rose tint to a dark cochineal-

red color. Finally the red color disappears and brown flocks are thrown down. The current of gas is continued until these flocks become of a clear orange tint. The liquid is filtered, the flocks washed with CS_2 and dried. On removing the NH_4Cl with water, washing again with CS_2 and drying, the nitrogen selenide is obtained pure, in amount equal to 80 per cent of the theoretical yield. It forms an amorphous orange powder, insoluble in all solvents, having the formula Se_2N_2. When dry it detonates violently by a shock, being as easily exploded as mercury fulminate, less easily than nitrogen iodide. Potassium hydrate and hydrogen chloride decompose it, producing selenite of potassium or ammonium.—*Bull. Soc. Ch.*, II, xxxviii, 548, Dec., 1882. G. F. B.

4. *On the Preparation of Carbonous oxide.*—NOACK, observing, in his reduction experiments with triphenylphosphites, the action of zinc dust upon carbon dioxide, has proposed this as a method of preparing carbonous oxide. For this purpose a somewhat wide combustion tube is used, filled with zinc dust for its whole length, a passage being left for the gas. This tube is heated to 400° in a furnace, and CO_2 is passed into it from an evolution flask, a wash-bottle containing Na_2CO_3 being inserted between it and the tube, and a second one containing potash solution at the farther end. With 200 grams of zinc dust, 20 liters CO can be obtained in a short time. Since the volumes of CO_2 and of CO are equal, the quantity of the latter obtained should equal the former; but in practice there is some loss, thirteen liters CO_2 yielding only eleven liters of CO. The gas is exceptionally pure.—*Ber. Berl. Chem. Ges.*, xvi, 75, Jan., 1883. G. F. B.

5. *On Molecular Compounds of Benzene and Naphthalene with Antimonious chloride.*—SMITH and DAVIS have observed that on melting a mixture of three parts of antimonious chloride and two of naphthalene, a beautiful crystallization commences on cooling, perfectly symmetrical monoclinic plates being produced. With some difficulty enough of these crystals were removed to be examined. They are very deliquescent and must be placed at once in a stoppered bottle. On analysis they gave numbers corresponding to the formula $(SbCl_3)_3(C_{10}H_8)_2$. If the $SbCl_3$ be dissolved in benzene, three parts of the former to four of the latter, and the corked flask be set aside for a few days, large well-defined monoclinic plates thinner and less regular than those of the naphthalene compound are produced. They are colorless and transparent, and are very deliquescent. On analysis they gave numbers agreeing with the formula $(SbCl_3)_3(C_6H_6)_2$.—*J. Chem. Soc.*, xli, 411, Dec., 1882. G. F. B.

6. *On Acetoxims, a new class of Organic bodies.*—JANNY, under v. Meyer's direction, has succeeded in producing a new class of organic bodies by the action of hydroxylamine upon various ketones. These new bodies he calls acetoxims, and an acetoxim he defines to be a body containing the group CNOH = (combined on both sides with carbon. If hydrogen saturates on one side) a body is formed to which he gives the name aldoxim. The

simplest acetoxim is dimethyl-acetoxim, $CH_3-CNOH-CH_3$, or acetoxim proper; analogous to dimethyl-ketone or acetone. It is produced by the action of hydroxylamine upon acetone in the cold in aqueous solution. It is easily soluble in water, alcohol and ether, fuses at 59°–60° and boils at 134·8°. Ethyl-methyl-acetoxim, methyl-pseudobutyl-acetoxim, methyl-phenyl-acetoxim, and diphenyl-acetoxim are described in the original paper.

PETRACZEK has studied the aldoxims in the same laboratory. He describes ethyl-aldoxim C_2H_5NO or $CH_3-CNOH-H$, propyl-aldoxim C_3H_7NO, and benzyl-aldoxim C_7H_7NO. They are formed by the action of hydroxylamine upon the respective aldehydes.—*Ber. Berl. Chem. Ges.*, xv, 2778, 2783, Dec., 1882. G. F. B.

7. *On the Synthesis of Uric acid.*—The synthetic production of uric acid has been accomplished by HORBACZEWSKI. Pure, finely pulverized glycocoll was mixed with ten times its weight of pure urea and heated quickly to 200° or 230° in a metallic bath being kept there until the colorless liquid became a yellow, turbid and pasty. After cooling, the mass was dissolved in dilute KOH, saturated with NH_4Cl and precipitated with a mixture of ammonia-silver solution and magnesia mixture. The precipitate after washing was decomposed with potassium sulphide. The filtrate was saturated with HCl, and concentrated. The crude product by solution in alkali and reprecipitation was purified. A yellowish crystalline powder resulted which possessed all the properties of uric acid. Under the microscope the crystals were plates or rhombic crystals. They reduced copper solution on warming and silver solution in the cold. They dissolved in nitric acid and left on evaporation an onion-red layer becoming purple red with ammonia and violet with potash. They are not soluble in water, alcohol, ether or acids, but soluble in alkalies, and gave the right formula on analysis.—*Ber. Berl. Chem. Ges.*, xv, 2678, Nov., 1882. G. F. B.

8. *The Radiometer.*—Much uncertainty still exists in regard to the phenomena exhibited by the radiometer. These phenomena are complicated by the action of the enclosing vessel, the rarefied medium and the constitution of the vane of the radiometer. ERNST PRINGSHEIM has made a careful study of the influence of the glass-containing vessel, of the enclosed gas and of the constitution of the vane. His apparatus consisted of one vane which was hung by a long bifilar suspension. A little mirror was placed upon the vane, and the movements of the latter were observed by means of a spot of light reflected upon a scale. His experiments lead him to believe that a pressure emanates from the heated side of the vessel, and that this pressure increases with the temperature and is independent of the nature of the material of the vessel. He finds that the absorption by the rarefied medium is extremely small and can be neglected. That the action of the vane is due to the rate of absorption and conduction on its two sides. He considers the theory of currents of the rarefied medium as untenable and believes that the kinetic theory of the radiometer is the

most reasonable one. The influence of the form of the radiometer vanes is due not to the form but to their proximity to the sides of the enclosing vessel. The difficulty of reconciling the various phenomena noticed in radiometers is due to the disturbing causes which result from the various forms of radiometers, and he therefore adopted the simplest instrument, a single vane suspended by a bifilar suspension.—*Ann. der Physik und Chemie*, 1883, No. 1, pp. 1–32. J. T.

9. *Measurement of wave lengths in the Ultra-red portion of the solar spectrum.*—The peculiarity of this measurement by Ernst Pringsheim, resides in the use of a radiometer to measure the heat. The spectrum produced by a Rutherfurd's grating, 17,296 lines to the inch, was examined by keeping all parts of the apparatus stationary except the grating; this was turned upon a vertical axis, and different portions of the spectra were thus thrown upon the radiometer. This radiometer consisted of but one vane, which was suspended by a long bifilar suspension. The radiometer was carefully protected from irregular disturbances by being placed in a suitable enclosure. By means of this apparatus, absorption bands were found from wave length $\lambda = 0{\cdot}0013658^{mm}$ to $\lambda = 0{\cdot}0013908^{mm}$. These results were modified by the absorbing media which were used to separate the spectra of different orders.—*Ann. der Physik und Chemie*, 1883, No. 1, pp. 32–45. J. T.

10. *Phosphorography of the infra-red of the Solar Spectrum.*—Henri Becquerel, in repeating the work of his father, has confirmed the results of the latter and has determined the wave length of a certain band of fine lines denoting the absence of phosphorescence which are analogous to the absorption bands known to exist in the infra-red. A Rutherfurd grating was employed and the spectrum was thrown upon various phosphorescent substances. A table of wave lengths is given, and the presence of maxima and minima of extinction of light peculiar to different phosphorescent substances is noted in the infra-red. Similar extinctions are known to exist in the ultra-violet.—*Comptes Rendus*, Jan. 8, 1883, pp. 121–124. J. T.

11. *Siemens' Theory of Solar Energy.*—M. Faye has pointed out that the centrifugal force at the sun's equator is too feeble in comparison with the force of gravity to enable the sun to play the role of a machine which takes in matter at the poles and throws it off at the equator. Siemens replied to this objection by using as an illustration Newton's tube, which the latter employed to show how the flattening of the earth could be determined. This tube had one of its branches directed along a line from the poles through the center of the earth, and the other from the center to a point upon the equator. Faye replies that Newton's ideal tube was supposed to terminate upon the surface of the globe, while the extremities of Siemens' tube extend indefinitely into space. Thus the sun will communicate his rotation to the entire medium pervading space; and this medium will therefore turn with the

sun—a consequence which M. Faye believes that Dr. Siemens cannot admit.—*Comptes Rendus*, Jan. 8, 1883, p. 79. J. T.

12. *The Effect of Oil upon Waves.*—In reply to an objection of Admiral Bourgeois that the actual effect of oil upon waves should be fully tested before it is submitted to theoretical analysis, M. G. VANDER MENSBRUGGHE, replies that he has shown from incontestable facts that the wind produces upon the superficial layer of the sea, a horizontal motion of translation, which being sufficiently prolonged can communicate to the deeper layers, and can propagate to a great distance, very decided undulations. He has confined himself to a discussion of two cases; in the first, where the calm sea is covered with a thin layer of oil and is then submitted to the action of the wind; in the second, where the waves break. In the first case the formation of great waves is rendered impossible by the presence of the layer of oil. In the second, a simple calculation shows that the layer of oil exerts a great resistance at the base of the breaker, and thus compels it to extend itself and to subside very rapidly without producing severe wave shocks.—*Comptes Rendus*, Jan. 2, 1883, p. 62–63. J. T.

13. *Rarefied Air as a Conductor of Electricity.*—EDLUND continues his researches upon this subject. A number of experiments are described to show that the phenomena of the opposition to the passage of sparks from terminal to terminal in rarefied air cannot be explained by the theory that a vacuum does not conduct electricity. He carefully discusses the question of the contrary electro-motive force which is developed at the terminals. "It is not the resistance of the gas but this electro-motive force, increasing with the rarefaction and connected with the electrodes, that presents an obstacle to the passage of the current. Everything is in favor of the hypothesis that vacuum opposes a very feeble resistance to the propagation of electricity." Without the employment of electrodes, one can excite an induction current in a Geissler tube, which is sufficient to produce light. This would be impossible if the highly rarefied gas or vacuum were an insulator.—*Phil. Mag.*, Jan., 1883, p. 1–22. J. T.

14. *Conference for the Adoption of a Standard Meridian and of a Standard Time.*—The Minister of Public instruction has informed the French Academy that a circular has been received from the United States Government, which invites the French Republic to convoke a conference of all nations, which shall consider the question of the establishment of a common initial meridian and a common hour.

This circular states:—

(1.) That the need of uniformity is a great source of trouble in commerce—especially since the great extension of railroad systems and telegraph lines.

(2.) This question has been long discussed, both in Europe and America, by scientific men and by business men, who recognize the need of a general understanding and coöperation.

(3.) That the initiative seems to belong to the United States,

on account of the great extent of its territory in respect to longitude.

The President of the United States, convinced of the advantages of the reform in regard to the question, accordingly desires to obtain the opinion of the French Government in regard to an international conference. This communication will be referred by the French Academy to a commission from the Section of Astronomy and from that of Geography and Navigation.—*Comptes Rendus*, Jan. 2, 1883, p. 42. J. T.

15. *An Introduction to the Study of Organic Chemistry;* by ADOLPH PINNER, Ph.D., Professor of Chemistry in the University of Berlin. Translated and revised from the fifth German Edition by PETER T. AUSTEN, Ph.D. F.C.S., Professor of Analytical and Applied Chemistry in Rutgers College and the New Jersey State Scientific School. New York: John Wiley & Sons, 1883, pp. xix and 403. 12mo.—Dr. Pinner's Introduction is probably our best text-book on organic chemistry. After 14 pages of the most essential explanations, the mono-carbon group or methane compounds are described, including methane and its various halogen, hydroxyl, sulphur, nitrogen (cyanogen bodies) and other derivatives. The order chosen is that which most naturally leads from the simpler to the more complex bodies. The descriptions are full or brief according to the importance of the substance, and the genetic and constitutional relations of the compounds are brought out in a clear and concise manner. The methane derivatives occupy sixty pages. The ethane derivatives follow in similar order; followed again by their homologues up to the hexa-carbon bodies. The carbhydrates and uric acid derivatives are treated separately. Then follows a retrospect in which the more important paraffine, olefine and acetylene hydro-carbons, their halogen and hydroxyl derivatives (including aldehydes, ketones and acids of various basicity), amines, etc., etc., are tabulated so as to emphasize their homologies. These topics fill one-half of the book. Then follow benzene and its homologues and derivatives well presented in 100 pages. Naphthalene, anthracene and their congeners; the camphors, essential oils, resins, pyridine bases, alkaloids, glucosides, coloring matters, bitter principles, biliary substances and proteine bodies, complete the descriptive part. An Appendix of thirty pages gives an account of the methods of elementary analysis, the determination of gas-densities, the study of "constitution," action of re-agents and atomic migration. A complete Table of Contents and Index are supplied.

The book, we understand, closely follows Professor A. W. Hoffmann's plan of instruction; it is written in a very simple, clear and appropriate style. The translation as well as the revision does great credit to Professor Austen, and we cordially commend the volume to teachers and students of this fascinating and now most "practical" branch of science. S. W. J.

16. *Uniplanar Kinematics of Solids and Fluids*, with applications to the distribution and flow of electricity; by GEORGE M. MINCHIN, M.A. Oxford, 1882. 8vo, pp. 266.—Professor Minchin limits himself in this book to motion which takes place in one plane or parallel to one plane. In fluids, for example, no displacements are supposed perpendicular to the plane *xy*. The extension of uniplanar theorems and formulas to motion in three dimensions can be more easily made after the leading conceptions are mastered. The first half of the volume is occupied with the subjects of displacement, velocity, acceleration, epicycloidal motion, mass-kinematics, and small strains. In the treatment of epicycloidal motion, especially, the author has introduced new theorems.

The last half of the volume is devoted to kinematics of fluids and notes. It will be appreciated by persons who undertake to read Clerk-Maxwell's *Electrictity and Magnetism*, to which it is an admirable introduction. The style of Professor Minchin is very clear and concise. H. A. N.

II. GEOLOGY AND MINERALOGY.

1. *Transactions of the Wisconsin Academy of Sciences, Arts and Letters.* Vol. V, 1877–81. Madison, Wis.—Professor T. C. Chamberlin has here a paper entitled "Observations on the recent Glacial drift of the Alps, based on personal observations." In it, after describing the *Jardin* (or Garden) in the Chamouni region as an area of grasses and flowers surrounded on all sides by perpetual snow and ice, he compares with it the "driftless area" of Wisconsin. He observes that the Jardin is not a driftless area, for it was formerly under the ice-sheet and has erratics on its surface; but in the present glacial condition, the glacier divides and passes around it to unite again below, leaving it so far as present action is concerned a non-glaciated area, surrounded on all sides by active glaciation. It is stated that the resemblance ceases here; for it is enclosed by a steep moraine, thrust up by the ice around it, while on the border of the Wisconsin driftless area the glacial debris thins out gradually and disappears in an obscure margin. Further, the Jardin lies on the lee side of a prominence, and owes its escape from ice "more to its own prominence than to the effects of adjacent depressions." The ice moving from the Archæan region south of Lake Superior, after a course of 100 miles, "terminated on the declivity, and its waters continued on across the driftless area, leaving gravel terraces along their course."

On page 276, Professor J. E. Todd describes fossil foot-tracks on Potsdam sandstone from a locality four miles north of New Lisbon. The tracks are in involved lines or bands, where broadest 4 to 4½ inches wide, and have the characters of *Climatichnites* of Logan. Mr. Todd names them *C. Fosteri*, and speaks of them as undoubtedly of animal origin. An excellent figure accompanies the article.

2. *Lower Devonian fossil-bearing metamorphic rocks in the region of Bastogne, Belgium (town of Luxembourg).*—A paper by A. Renard, on the lithology of these metamorphic Devonian rocks, is published in Volume I (1882) of the Bulletin of the Belgian Royal Museum of Natural History. The beds belong to the middle member of the Coblentzian group of Dumont, called the Taunusian. The metamorphism and fossiliferous feature of the rocks were recognized by Dumont. The fossils *Spirifer macropterus*, *Chonetes sarcinulatus* and others, occur in a garnetiferous schist and quartzyte, besides remains of plants. The rocks include a hornblendic or actinolitic eurite, garnetiferous and chloritic quartzytes, garnetiferous fossil-bearing quartzyte, and chloritic garnetiferous schist also fossiliferous. M. Renard has studied the rocks both by chemical analysis and the microscope. He found in the hornblendic quartzyte, 30·62 of quartz, 37·62 of hornblende, 20·85 of mica, 4·14 of garnet, 1·02 of titanite, 1·51 of apatite, and 4·80 of graphite (visible in scales), with some ottrelite. The actinolitic rock consists of quartz 52·36, hornblende 46·73, with traces of titanic iron, mica and graphite. The hornblende (actinolite) is in interlaced fibers. The garnetiferous slate consists chiefly of biotite and garnet, with graphite in scales, and rarely hornblende. It graduates into the quartzyte. The author discusses also the origin of the metamorphism, and gives analyses of the ottrelite.

3. *On a large mass of Cretaceous Amber from Gloucester Co., New Jersey;* by GEO. F. KUNZ. (Read before the New York Academy of Sciences, February 5th, 1883.)—About twelve months ago a mass of amber of uncommon size and shape (being twenty inches long, six inches wide and one inch thick, and weighing sixty-four ounces), was found at Kirby's marl pit, on Old Man's Creek, near Harrisonville, Gloucester Co., New Jersey. A one-quarter inch section showed a light grayish yellow color. A section one and one-quarter inch thick showed a light, very transparent yellowish brown color. The entire mass (surface and interior) was filled with botryoidal-shaped cavities filled with glauconite or green sand, and a trace of vivianite. The hardness is the same as the Baltic amber, only slightly tougher and cutting more like horn, and the cut surface showing a curious pearly luster, differing in this respect from any other amber I have yet examined. This luster is not produced by the impurities, for the clearest parts show it the best. It admitted of a very good polish. The specific gravity of a very pure piece of the carefully selected amber is 1·061, which is the lowest density on record, the usual amber range being from 1·065 to 1·081. It ignites in the same way as other ambers. It was found at a depth of twenty-eight feet, in and under twenty feet of the green sand or marl, the amber being found in a six-foot stratum of fossils, consisting mostly of *Gryphea vesicularis*, *Gryphea Pitcheri*, some *Terebratula Harlani* and others; the upper part of the marl, consisting of a large layer of limestone several feet in thickness, filled with

Palorthis, Echinoid spines and an occasional shark's tooth of the genus *Lamna*, and this covered with eight feet of earth. The marl belongs to the middle bed of the upper Cretaceous series.

No analysis has as yet been made of this amber, but the similarity in specific gravity, hardness and ignition leaves little doubt of its being true amber, or of its having been derived from a gum closely resembling that which is the source of the Baltic and other ambers.

III. Botany and Zoology.

1. *Apropos des Algues Fossiles, par le Marquis de Saporta.* Paris: Masson. Imp. 4to, pp. 82+10. 1882.—Nathorst, a distinguished Swedish naturalist, after making a series of observations and experiments upon the tracks and traces made by various invertebrate animals upon a beach or upon other soft and plastic material, published a paper (in 1881) in which he lays down the conclusions that no small part of the markings which have been described as fossil *Algæ* are simply the vestiges of such traces. And he pronounces this to be true of most of the fossil *Algæ* described in Saporta's *Paléontologie Française* and in his later and more popular volume, *L'Evolution du Règne Végétal.* The present volume is a courteous and magnificent reply to Nathorst's criticism—magnificent, for he devotes to it this beautiful imperial quarto volume, illustrated by figures interspersed in the text, as well as by ten lithographic plates,—courteous, for he over and over acknowledges the entire correctness of his adversary's facts and his conscientiousness in deducing from them such damaging conclusions. But he proceeds to rebut Nathorst's inferences as to most of the objects in question, by rehearsing the whole evidence in detail and presenting a series of figures, beginning with the most unequivocal instances, passing on to those that may be questionable, and allowing that the laudable desire of the phyto-paleontologists to include in their survey all the plant-like markings they know has led them to notice and describe not a few which are susceptible of the interpretation given by the Swedish naturalist. But to the greater part Saporta insists that the adverse conclusions are far-fetched, forced, founded on a preconception, and in certain cases capable of complete disproof. Also that some of the most dubious markings, which might well receive Nathorst's explanation, have been found quite closely imitated by the traces of an *Ulva.* A. G.

2. *Les Plantes Potagères, Description et Cultures des Principaux Légumes des Climats Tempérés;* par Vilmorin, Andrieux & Cie. 1883, pp. 650, 8vo. Paris.—Besides its importance to cultivators, this volume—prepared by a most competent and trusty hand, and issued by the noted house of Vilmorin, Andrieux & Co.—has no small botanical value. It treats of the kitchen-garden plants of temperate climates, with considerable fulness and abundant illustration from original sketches. It refers the varieties and races to their proper botanical species, the native country of which is

indicated with all the correctness to which recent researches have attained. So that this book, as far as it goes, is a good companion and supplement to the contemporary *Origine des Plantes Cultivées*, by DeCandolle, a notice of which is still due to our readers. Among the interesting matters contained in the Introduction, we note the statement of the author that cultivation, even where immemorial, has in no wise effaced the limit of species. A. G.

3. *The Colors of Flowers;* by GRANT ALLEN. Macmillan & Co. 1882.—This taking little book, in which a popular subject is very interestingly treated, originated as an article in the Cornhill Magazine, was extended into a series of articles in *Nature*, and now the latter are reëdited and collected in a volume of *Nature Series*. We need only notice the distinguishing feature of a contribution to evolutionary science which must already have been widely read. The "central idea" is that petals are transformed stamens, rather than transformed leaves. The argument is, that the earliest flowers consisted only of stamens and pistils, one or both; that the original color of these was yellow, that consequently (by inheritance) the stamens of almost all flowers are yellow,—whence "it would seem naturally to follow that the earliest petals would be yellow too." Now "the earliest and simplest types of existing flowers [i. e. the petals of such as have any] are almost always yellow, ... and this in itself would be a sufficient ground for believing that yellow was the original color of all petals." The author thence proceeds to show how this color is changed into others, white, red, &c., up to blue, in a normal succession.

The experienced botanist, looking at the facts irrespective of theory, will raise some questions. Is it actually true that most of the simpler flowers with colored perianth are yellow, and that this color is conspicuously absent from highly differentiated and attractive flowers? No numerical proof of it is offered, and we suppose no convincing proof is to be had from observation. Yellow vastly preponderates in the very largest of the highly differentiated orders of plants, and holds a fair share in the two next largest (*Leguminosæ* and *Orchideæ*). Exception may also be made to the fundamental premise that the stamens of almost all flowers are yellow. The pollen is prevailingly of this color, and so more commonly may be the anther, but rarely the filament, the dilatation of which is assumed to give rise to petals:—to give rise, moreover, to the sepals also, if the theory holds, at least when they are colored. But how when they are green and herbaceous? And how is the line to be drawn; and if colored sepals originated from stamens, why not subtending bracts as well, when these are petaloid?

Our author says: "We can see how petals might easily have taken their origin from stamens, while it is difficult to understand how they could have taken their origin from ordinary leaves, a process of which, if it ever took place, no hint now remains to us." But either we have a hint in the brilliant bracteal

leaves of Painted-cup, Poinsettia, and *Salvia splendens,* or these attractive leaves have also taken their origin from stamens! Whether we choose to regard petals and other perianth-members as modifications of stamens or as modifications of green leaves is, according to our thinking, mainly a question of mode of conception. Some good morphological evidence may be adduced for either. Mr. Allen's study of the case by evolutionary deduction is interesting and suggestive. It has the advantage of making an appeal to facts open to observation. We are by no means convinced that the facts sustain it. A. G.

4. *Direct observation of the movement of Water in Plants.* M. Julien Vesque (Ann. des Sc. Nat., XV, 1) has devised a simple method of demonstrating the transfer of water in the stems of plants, which promises to have a wide application. The stem is cut obliquely during immersion in water, and the thin part of the severed stem is placed in the field of the microscope, of course completely wet on the cut surface. After the cover-glass is adjusted and the stem is securely fastened, so that it cannot be easily disturbed by subsequent treatment, a very little freshly precipitated calcium oxalate, or other finely divided substance, is introduced under the cover. If the leaves have not been removed from the stem, a rapid current is at once observed to flow towards the cut surface. The insoluble salt collects at the open mouths of the vessels, often passing into the capillary tubes after a temporary arrest, and the same phenomenon is repeated several times as the minute plugs are formed and then sucked in.

With low powers of the microscope it is possible to use a second slip instead of the thin cover, and then the simple apparatus can be held more firmly in its place. In any case it is possible to measure the rapidity of the current by means of a micrometric eye-piece; and several such rates are given.

When the stem is quickly stripped of its leaves the current is stopped at once. But when, on the other hand, a leaf or a part of the stem is pinched, there is immediately a backward flow of water.

It is well known that two conflicting views have been held by physiologists as to the channel by which the upward movement of water in wood takes place. Some think that the transfer is solely by imbibition, and that no free water is carried from cavity to cavity of the wood-element, or rather, that no free water exists in the cavities. Others have held that free water is carried from one wood-element to another, and that the walls themselves play only a subordinate role. To these opposed views may be added a third, which appears to be a compromise; namely, that water in a free state actually exists as a thin lining on the cell-wall. The chief advocate of the latter view has however abandoned it in favor of the imbibition theory. A recent publication by Elfving (Bot. Zeit. Oct. 1882) details the results of experiments which considerably strengthen the "cavity" theory. Now just at this point come observations of Vesque, in a continuation of the paper regarding the method of direct demonstration, which

go far towards showing that here, as was long ago suspected, the truth is to be found between the extremes. These experiments, which need to be carefully repeated, indicate that under certain circumstances the transfer of water takes place by means of the cavities themselves, but that in all cases they may serve the part of reservoirs.

Moreover, the caliber and length of the vessels regulate the rate of transpiration; resistance to the movement of the water following the law of Poiseuille, so that the resistance is inversely proportional to the fourth power of the diameter and directly proportional to their length. We give in full the close of Vesque's paper:

"It is evident that p having reached its maximum, that is to say the suction resulting from transpiration not being able to increase without changing our conditions, because the air dissolved in the water becomes disengaged, the quantity of water which arrives at the organs of transpiration across a vessel filled with water is expressed by $\frac{Ad^4}{l}$. From this we can see why climbing plants have such large vessels; in fact, the increase in diameter can alone compensate that of the length. And, further, the quantity of water which can pass through a vessel in a given time bears a certain relation, varying for each species, with the water which it contains: this, which I have called the transpiratory reserve, it might be better to term the vascular transpiratory reserve. I propose to publish a work on water reservoirs in general. A study of this apparatus very often gives the key as to the resistance of certain plants to certain surroundings, and permits us to indicate at once the conditions under which we must cultivate plants. Anatomy, I am convinced, will open the way to rational culture." G. L. G.

5. *The stalked Criniods of the Caribbean Sea;* by P. Herbert Carpenter, Bulletin of the Museum of Comparative Zoology, vol. x, No. 4, Dec., 1882.—This paper is a Report on the Dredgings of the Coast Survey Steamer Blake, in the Gulf of Mexico and Caribbean Sea, in 1877–1879, under the supervision of A. Agassiz. This report contains descriptions of four species of *Pentacrinus* (out of the eight known), and two of *Rhizocrinus: P. asteria, P. Mülleri, P. decorus* and *P. Blakei* (here new), *R. Lofotensis* and *R. Rawsoni.* They were obtained at depths between 73 and 955 fathoms, but mostly between 80 and 400. Mr. Carpenter states that stalked crinoids have been obtained at depths exceeding 650 fathoms only in fourteen instances, the lowest limit being 2,435 fathoms for *Bathycrinus gracilis,* found by the Porcupine in 1869; that *P. Wyville-Thomsoni* was obtained by the Porcupine in 1,095 fathoms in 1870: *P. Naresianus,* at 1,350 fathoms, by the Challenger in the Pacific; that *Bathycrinus* ranges from 1,050 to 2,435 fathoms, *Hyocrinus* from 1,600 to 2,325; while *Rhizocrinus Lofotensis* occurs in the Norwegian fiords at 80 fathoms, and in 175 to 955 in the Caribbean Sea.

Mr. Carpenter adds "it is a pity that we have no later knowledge of the "Australian Encrinite," a stem six inches long, which was obtained by Poore (Ann. Mag. Nat. Hist., ix, 486, 1862), at a depth of 8 fathoms in King George's Sound."

6. *Selections from Embryological Monographs*, compiled by A. AGASSIZ, WALTER FAXON and E. L. MARK. I. *Crustacea*, by W. FAXON, with 14 plates. Memoirs of the Museum of Comp. Zool., vol. ix, No. 1, 4to.—This volume is the beginning of a series of publications which will constitute a most generous contribution to American science by the Museum of Comparative Zoology. The fourteen crowded but admirably engraved plates contain full illustrations of the embryological development of various species of Crustacea, Limulids and Pycnogonids, derived from recently published Memoirs. The authors cited from include, besides Mr. Faxon and Professor A. Agassiz, Fritz Müller, W. Lilljeborg, Carl Claus, E. and P. J. Van Beneden, E. Melschnikoff, N. Bobretzky, F. Richters, Paul Mayer, B. Ulianin, L. St. George, H. Reichenbach, H. Rathke, Anton Dohrn, A. v. Nordmann, C. Grobben, P. P. C. Hoek, C. Darwin, T. H. Huxley, C. Spence Bate, J. Barrande, G. Hodge, W. K. Brooks and A. S. Packard, Jr.

Transactions of the Linnæan Society of New York. Vol. I. 168 pp. large 8vo. Published by the Society, Dec., 1882. New York.—This handsomely printed volume contains the following papers: The Vertebrates of the Adirondack region, Northeastern New York (Carnivora), by C. H. MERRIAM, M.D.; Is not the Fish-Crow (*Cervus ossifragus* Wilson) a winter as well as a summer resident at the northern limit of its range? by WM. DUTCHER; A review of the summer birds of a part of the Catskill Mountains, with prefatory remarks on the Faunal and Floral features of the region, by E. P. BICKNELL.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Cold of January in Iowa.* From the Iowa Weather Bulletin for January, 1883; by GUSTAVUS HINRICHS.—The great cold spell from the 10th to the 23d has been of so extraordinary a character that possibly the following table, giving the temperature of the air as registered by the standard thermometer at the Central Station may be of interest. The minus sign — indicates degrees below zero, Fahrenheit.

January.	Friday 19.	Sat. 20.	Sun. 21.	Mon. 22.	Tues. 23.	Wed. 24.
2 A. M.	21	−12	−24	−20	−18	0
4 A. M.	21	−11	−25	−21	−18	1
6 A. M.	5	−12	−22	−22	−18	0
8 A. M.	− 8	−12	−18	−22	−19	0
10 A. M.	− 9	−13	−13	−15	−17	5
Noon	− 9	−13	−10	−10	−11	12
2 P. M.	− 8	−12	− 9	− 8	− 6	16
4 P. M.	− 8	−12	−10	− 7	− 6	15
6 P. M.	−10	−14	−14	−10	− 6	14
8 P. M.	−12	−18	−16	−13	− 4	10
10 P. M.	−13	−20	−18	−14	− 2	9
Midnight	−13	−23	−19	−15	0	5

2. *Report on the Climatic and Agricultural Features and the Agricultural practice and needs of the Arid regions of the Pacific slope, with notes on Arizona and New Mexico.* Made under the direction of the Commissioner of Agriculture, by E. W. HILGARD, T. C. JONES and R. W. FURNAS. 182 pp. 8vo. Washington, 1882.—This report is full of valuable facts and discussions respecting the agricultural and other field-resources of the Pacific slope, and particularly of California. The special subjects are: climates, soils, timber and forest culture, causes of aridity, irrigation, alkali lands and methods of improvement, analyses of soils and waters, California wines and brandies, with notes on exotic fruits and useful plants on trial at the Agricultural College of the University of California, and on the Phylloxera in California, by E. W. Hilgard; on field crops and animal industries, by T. C. Jones; on the standard sugar refinery, Alvarado, California, raisin making, olive industry, etc., by R. W. Furnas.

3. *Astronomical and Meteorological Observations made during the year* 1878, *at the U. S. Naval Observatory.*—The two appendices in this volume, Professor Holden's Monograph on the Nebula in Orion, and the Longitude of the Observatory at Princeton, N. J., have already been noticed in this Journal. The volume contains, besides these, the regular observations made at the Naval Observatory with the large and small equatorials and the transit circle.

4. SCIENCE.—The first number of Science, the prospectus of which was noticed on page 87, appeared on the 9th of February.

Report of an examination of the Upper Columbia River and the territory in its vicinity in September and October, 1881, to determine its navigability, and adaptability to steamboat navigation, made by direction of the Department of the Columbia, by Lieut. T. W. SYMONS, Corps of Engineers, U. S. A. 134 pp. roy. 8vo, with maps. Washington. 1882.

Bulletin of the U. S. Fish Commission, Spencer F. Baird, Commissioner, vol. I, 1881, 466 pp. 8vo. Washington. 1882.

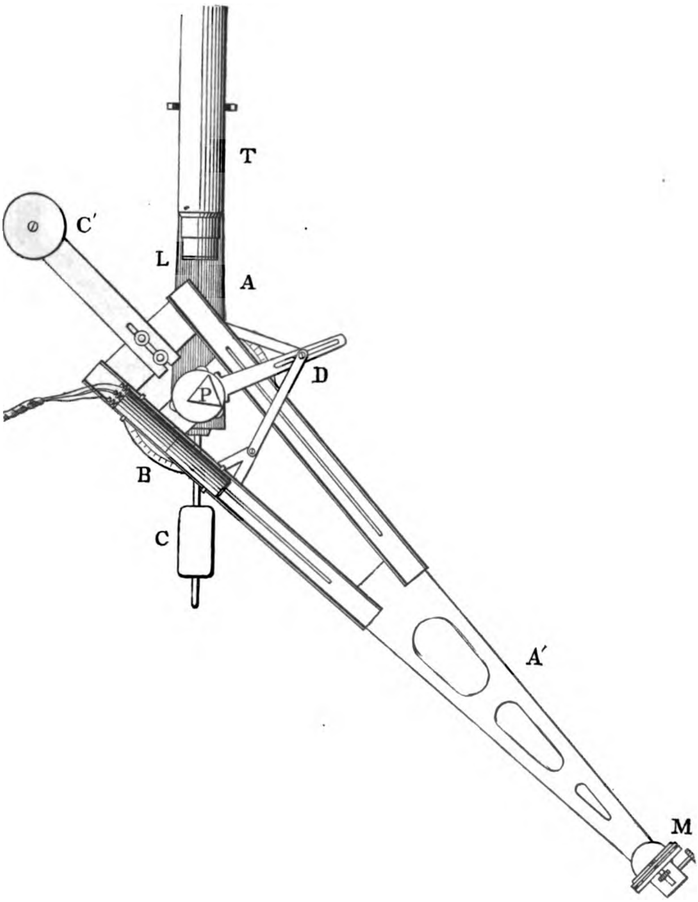
The American Palæozoic Fossils, of S. A. MILLER, Cincinnati. 334 pp., large 8vo. This second edition of Mr. Miller's useful work, mentioned on page 474 of the last volume of this Journal as in the press, has been published. The additions cover 90 pages.

Report of the Entomologist to the Department of Agriculture for the year 1881, by CHARLES V. RILEY, M.A., Ph.D. 214 pp. 8vo, with 19 plates, partly colored.

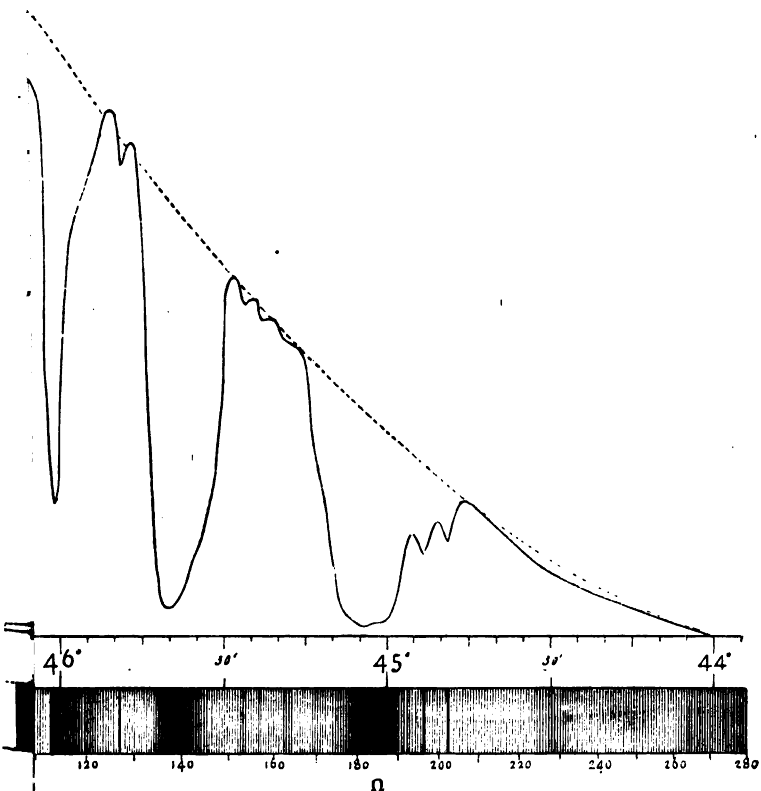
Die elektrische Kraftübertragung und ihre Anwendung in der Praxis. Mit besonderer Rücksicht auf die Fortleitung und Vertheilung des elektrischen Stromes: dargestellt von Eduard Japing, dipl. Ingenieur. 236 pp. 12mo, with 45 cuts. Wien and Leipzig (A. Hartleben) Elektrotechnische Bibliothek, Band II.

OBITUARY.

ALEXIS PERREY, eminent for his long-continued labors in connection with the department of Earthquakes, and Honorary Professor of the Faculty of Sciences at Dijon, died at Paris, on the 29th of December last, in his 76th year.



Spectro-bolometer.



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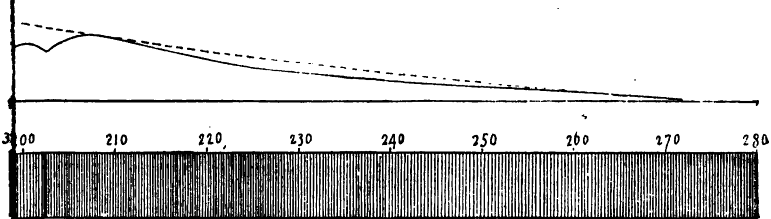
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THE

AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

ART. XXVII.—*Review of DeCandolle's Origin of Cultivated Plants;* with Annotations upon certain American Species;* by ASA GRAY and J. HAMMOND TRUMBULL.

M. ALPHONSE DE CANDOLLE'S *Géographie Botanique Raisonnée*, in two volumes of nearly 700 pages each, was published in the year 1855, and has been for several years out of print. It is not surprising that the now venerable but still well-busied author should decline the labor of preparing a new edition, involving, as it would, the re-discussion of certain questions under changed points of view, and the collocation of a vast amount of widely scattered new materials which the last quarter of a century has brought to us.

Happily, the chapter on the geographical origin of the species of plants generally cultivated for food, and for other economical uses, could be detached. This, the author has sedulously studied anew; and the present volume is the result. As yet we have it only in the original French; but it is said that an English translation is in preparation. So, if the work is not already in the hands of botanists and other scholars generally, we may expect that it soon will be; and, contenting ourselves with a mere mention of its plan and scope, we may proceed to

* *Origine des Plantes Cultivées*, par ALPH. DE CANDOLLE, Associé Etranger de l'Academie des Sciences de l'Institut de France, etc. Paris, 1883, pp. 377, 8vo. (Bibl. Scientifique Internationale, XLIII.) Baillière et C^{ie}.

remark, here and there, upon points which strike our attention.* We may expect this to be for many years the standard work upon the subject, and to undergo revision in successive editions; and we are sure that the excellent author will welcome every presentation or discussion which may chance to throw any new light upon the sources or the aboriginal cultivation of certain plants which the Old World has drawn from the New.

The first part of the volume, of only 22 pages, is mainly occupied with a consideration of the means employed for the determination of the sources whence the various cultivated plants have been derived. The botanist enquires where a given cultivated plant grows spontaneously, or what was its wild original; and he has to judge, as well as he can, where it is truly indigenous or where a reversion from a cultivated to a wild condition. This, as respects weeds and the like, is a difficult matter, even in a newly settled country like North America, much more so in the Old World; but as respects the plants of agriculture, the case is usually simpler. The botanists resident in a country are not likely to be far misled by the occurrence of *wilderings;* but, in the case of travelers and collectors, perhaps too much has been made, even in this volume, of plants only once met with growing spontaneously, and inferred to be indigenous. Plentifulness is of no account, else the Century plant and Opuntia would be thought indigenous to the Mediterranean region; the Ox-eye Daisy to the United States, and certainly the Cardoon to the Pampas, where there is now probably more of it than anywhere in the Old World. Archæology and palæontology are often helpful, as by the identification of fruits and seeds in ancient Egyptian tombs, or of paintings upon their walls, or of fragments in ancient bricks; or the *débris* of lake-dwellings rescued from lacustrine deposits, as in Switzerland; and from the tufas of Southern France, the kiökenmöddings of Scandinavia, the mounds of North America, and

* To avoid repetition, it may be mentioned here that, in the following annotations, the Relations of the Voyages of Columbus are cited from Navarrete's *Coleccion de los Viajes*, etc. (Madrid, 1858, and 1827–37); references to PETER MARTYR D'ANGHIERA's first three Decades *De Rebus Oceanicis et Novo Orbe*—written before 1517—are to the Cologne edition of 1574; references to OVIEDO's *Historia General y Natural de las Indias*—of which the first nineteen books, published in 1535, included a revised and enlarged edition of his [Relacio sumaria] *de la Nat. Historia de las Indias*, printed in 1526—are to the edition published by the Royal Academy of History, of Madrid, 1851–55; JEAN DE LERY'S *Histoire d'un Voyage faict en la terre du Brasil* (in 1557–8) is referred to in his revised edition in Latin, *Historia Navigationis in Brasiliam* (Genevæ, 1586); FR. HERNANDEZ, *Nova Plantarum*, etc., *Historia*, in the edition of Rome, 1651; *Rariorum Stirpium Historia* by L'ECLUSE (Clusius), in the first edition, Antwerp, 1576; his *Exotica*, including his translations of Monardes and Acosta, Antwerp, 1605, with his *Curæ Posteriores* (posthumous), 1611. J. H. T.

Il va sans dire—yet should explicitly be said—that all the historical and philological lore, which gives this article its value, is contributed by my associate.

A. G.

the ancient monuments and tombs of Mexico and Peru. Historical documents are also important for the date of certain cultures in particular countries; and here it is stated that the principal cultures have come from three great regions, viz: China, Southeastern Asia and Egypt, and intertropical America. DeCandolle also remarks that in the Old World agriculture was developed along rivers, in the New, upon plateaux, —a fact which he attributes to the primitive situation of certain plants worth cultivating. But this is not quite obvious. Linguistic learning may be turned to much account; as in tracing a plant towards its home by the name which has gone forth with it in all its migrations. Like other instruments this must be used with some knowledge and judgment. *Blé de Turquie* (maize) did not come from, and probably not by way of, Turkey, any more than did the animal of that name. *Jerusalem Artichoke* has nought to do with Jerusalem, but came from North America, and is no artichoke. *Pomme d'Acajou*, anglice, Mahogany-apple, is neither an apple nor a pomaceous plant, nor has it anything to do with mahogany. New Zealand Flax came indeed from New Zealand, but is not a Flax. Among errors from the careless transference of names from one plant to another, that of Potato, which belongs to the *Batatas* or Sweet Potato, is familiar. Of mistakes which have been made in the transference of a popular name from one language to another, DeCandolle mentions the *Arbre de Judée* of the French, which in English has become Judas-tree. We may add that of *Bois fidèle*, of the French West Indians, which, taken up by their English successors as Fiddle-wood, has been perpetuated in the generic name *Citharexylum.*

The several lines of evidence,—botanical, archæological, palæontological, historical, and linguistic—may be used to supplement or correct each other. How they may be brought to bear, and how their combination may give satisfactory results, is practically shown in Part II,—a study of the species as regards their origin, their earliest culture, and the principal facts of their dispersion,—which makes up the principal bulk of the volume, viz: from p. 23 to p. 350.

This part is divided into Chapters, e. g. Plants cultivated for their subterranean parts, such as roots, bulbs, tubers, etc. Those cultivated for their herbage, whether for human food, for forage, for fibers, for stimulation, etc.; but the proper medical plants are left wholly out of view, as likewise plants cultivated for ornament. So the chapter on plants cultivated for their blossoms, or parts connected with these, is brief enough,—treating as it does only of the Clove, Hop, Safflower and Saffron. For the Rose, Acacia Farnesiana, and all plants however largely cultivated for perfume or for essential oils are

left out of view. So also are the sweet-herbs of the kitchen garden, and all condiments, except Horse-radish. Plants cultivated for their fruits and seeds occupy the closing chapters. Among the latter the Cotton-plant is placed. The arrangement matters little, and that adopted may be the most convenient. A good index makes ready reference to any topic.

In the order of the book we come first to *Helianthus tuberosus*, the *Topinambour* of the French, Jerusalem Artichoke of the English; in the United States the tubers simply called artichokes. Almost all we know of the origin and source of these esculent tubers has been recovered since the publication of DeCandolle's earlier work, in 1855. Although the contemporary accounts specified its introduction from Canada, and Linnæus so cites it in the Hortus Cliffortianus, the subsequent reference to Brazil was followed without question down to DeCandolle's Prodromus; and the present author, in the work above mentioned, doubted the Canadian as well as the Brazilian origin. It now appears that Schlechtendal (in Bot. Zeitung, 1858) was the first to recover a part of the documentary history. Our own article on the subject—to which there is nothing of importance to add—was contributed to this Journal for May, 1877.* Singularly, it has remained unknown to DeCandolle, although it is referred to at the close of Decaisne's independent and exhaustive article, in the Flore des Serres, 1881.

It can now be said that the wild plant to which *Helianthus tuberosus* has been traced is not *H. doronicoides* Lam., although it was confounded with that species in Torrey and Gray's Flora. Lamarck's plant is a sessile-leaved species. Decaisne's remark that *H. tuberosus* is the only species of the genus which is at all tuberiferous may be qualified. A form of what appears to

* In it reference was made to Lescarbot's mention of roots "grosses comme naveaux . . . ayans un goût retirant aux cardes," etc., and cited his *Histoire de la Nouv. France*, in the edition of 1612 (p. 840). In a subsequent edition (1618), cited by M. DeCandolle, Lescarbot adds that he had brought these roots into France, where they began to be sold under the name of *Topinambaux*, and that their Indian name was *Chiquebi*. On this last point, Lescarbot was wrong. *Chiquebi* was an eastern Algonkin name for the tubers of *Apios tuberosa*, the common "ground nuts,"—not for those of *Helianthus tuberosus*. It is easy to see how Lescarbot was misled. Father Biard's *Relation de la Nouv. France* was printed in 1616, and in it (chap. 22) there is mention of certain "racines, appellées en Sauvage *Chiquebi*," which grow spontaneously under oaks: "elles sont comme des truffes, mais meilleures, et croissent sous terre *enfilées l'une à l'autre en forme de chapelet*," etc. Lescarbot doubtless caught the name from Biard, and misapplied it. Father Paul Le Jeune (*Relation*, 1634, chap. 7) mentions these ground-nuts, "une racine que nos François appellent des *chapelets*, pource qu'elle est distinguée par nœuds en forme de grains." Lescarbot's "Topinambaux" indicates a popular belief, in France, in the Brazilian origin of H. tuberosus. The Tupinamba Indians of Brazil—a division of the Tupi-Guarani family—had been allies of the French in the 16th century, and their name was probably well known in France through the relations of J. de Lery and other voyagers. Lescarbot (*Hist. de la N. F.*, 1612, p. 178) follows Lery in writing the name *Tououpinambaoult*. J. H. T.

be *H. giganteus*, but is not yet very well known, grows in Minnesota and the Saskatchewan region, has been mentioned by Douglas under the name of Indian potato of the Assiniboine tribe, by Bourgeau as "*H. subtuberosus*," in herb. Kew, and by Dr. C. C. Parry in Owen's Minnesota Report, p. 614, under the name of *H. tuberosus.* The scanty tubers which we have seen in dried specimens do not compare well with those of *H. tuberosus;* and that species has never been found wild so far north (that we know of), not even in the most southern parts of Canada West. The aborigines who cultivated it must have obtained it from the valleys of the Ohio and Mississippi and their tributaries, where it abounds.

Helianthus annuus L.,—the history of which was almost equally confused, and which we had identified with a widespread species of the Western United States—is omitted by DeCandolle, yet might claim a place: for Decaisne, who has treated it at length in the paper above cited, informs us that a form of it (called Russian Sunflower) is cultivated in Russia, for the oil of its large seeds, and, if we mistake not, for fattening poultry. Our Indians also cultivated it for the oil of the seeds, which they used for greasing their hair, also for eating and other purposes. Champlain noted this (in 1610?), and Sagard about a dozen years later.* The latter says (*Histoire du Canada*, 1636, p. 785): "Ils font estat du tourne-sol, qu'ils sement en quantité, en plusieurs endroits à cause de l'huyle qu'ils tirent de la graine," etc., piously adding: "Mais comment est-ce que ce peuple sauvage a pû trouver l'invention de tirer d'une huyle que nous ignorons, sinon à l'ayde de la divine Providence." The wild original of this Sunflower must have

* Champlain's earlier record of the cultivation and use of the Sunflower is essentially like that of Sagard, and both relate to the same stations, namely, the Huron towns near the southeastern point of Georgian Bay. This Champlain reached by way of the Ottawa (R. des Prairies) and Lake Nipissing. The lamented Decaisne has here introduced some confusion into the history, which we hasten to rectify. In his article in the *Flore des Serres* (xxiii, p. 108, p. 2 of the pamphlet), he says, "Je trouve dans Champlain l'observation suivante (*Voyag. Nouv. France*, réimpress. 1830, tom. i, p. 110):"

" En remontant le St. Laurent et avant l'arriver au Lac Ontario, je visitai cinq des principaux villages fermés de palisades de bois, jusqu' à Cahiagué," etc., and so on to the mention of the "grande quantité de bled l'Inde (Maïs) qui y vient très beau, comme aussi des citrouilles, Herbe des soleil, dont ils font de l'huile, de la graine de laquelle ils se frottent la tête."

This, the latitude of 44.50° being stated, would refer Cahiagué and the Sunflower cultivation to the neighborhood of Ogdensburgh and Prescott, far away from the actual place (the Indian town mentioned being the Huron name of the mission station of San Jean Baptiste, in what is now Simcoe Co.), and it introduces a palpable anachronism, "Ontario" having been an unknown name in Champlain's time. In fact, there is nothing answering to the early part of this pretended quotation, either in the original of Champlain or in the edition here cited by name and page. The excellent Decaisne could never have tampered with the quotation himself. He must have taken it at second hand and neglected to verify it.

been obtained by the Canadian Indians from beyond the Mississippi, and some degrees farther south. Judging from the breadth of the flower-heads soon after its introduction into Europe, it must in aboriginal hands have assumed much of the abnormal development which distinguishes the cultivated Sunflower from its wild original of the western plains.

Solanum tuberosum L.—The question of the Potato was fully discussed by DeCandolle in 1855; and the present review of it only confirms the now generally admitted conclusions. These are summed up in the statements, that the plant is spontaneous in Chili under a form quite identical with the cultivated species, that its aboriginal cultivation had extended as far north as New Grenada, but apparently no farther; that allied tuberiferous species, which our author regards as distinct (though others partly doubt it) are found along the Andes and through Mexico, and within the borders of the United States; that when known in Virginia and North Carolina in the second half of the 16th century, it was not derived from our Indians; and that it was carried to Europe first by the Spaniards between 1580 and 1585, and afterwards by the English.

Batatas vulgaris Choisy, *Convolvulus Batatas* L., the *Sweet Potato*, is one of a few cultivated plants which have attained to a very wide distribution over the warmer parts of the world in early times; and it is one which no botanist pretends to have seen in a truly wild state. The evidence inclines to an American origin; but it had reached the Pacific islands in prehistoric times, and was cultivated in China in the second or third century of our era. DeCandolle states that:—

"Clusius, one of the first to speak of the Batatas, says that he had eaten it in the south of Spain, where it was said to have come from the New World. He indicates the names of *Batatas, Amotes, Ajes.*"

The testimony of Clusius (L'Ecluse) to the American origin of the Sweet Potato, though not of the highest value, might be more strongly stated. He visited Spain and Portugal in 1566. The first edition of his *Historia Rariorum Stirpium* was printed in 1576, and contains the description of *Batatas*, which M. DeCandolle cites from the edition of 1601. He gives a figure of the plant, of which, he says he had observed three varieties growing in the south of Spain. He states their American origin, not as a doubtful matter or with a "l'on pretendait," but as a well established fact: "Spontè nascitur in novo orbe, vicinisque insulis, unde primum in Hispaniam delata est." "Now," he adds, "it is planted in many places near coast of Andalusia; but those grown at Malaga are preferred, and are transported to Cadiz and Seville. We sometimes have them fresh in Belgium, but they will not germinate here, the

country being too cold." As to the *name*—he was as undecided as have been some botanists since his time: "the Spaniards call them *Batatas*, and also *Camotes* or *Amotes*; some also *Ajes;* yet, as they say, they differ among themselves, and the root of *Batatas* may be much the sweeter and the more tender."

This confusion of names dates from the time of Columbus—for Clusius was not, by half a century, the first to speak of the *Batata.* (It may be worth noting, in parenthesis, that *Batatas*, the specific name adopted by Linnæus, and as the name of a genus by Choisy, is the Spanish *plural* of Batata, the aboriginal name.) Even Peter Martyr and Oviedo do not agree, in all particulars, as to the distinction between *Ajes* and *Batatas*—a distinction which both recognize. In the 9th book of his second Decade, written about 1514, Peter Martyr (ed. 1574, p. 191) describing the fruits, etc., of the province of Uraba, Darien, names, for the first time, *Batatæ:* "They dig from the earth," he says, "roots that *grow spontaneously* (*suapte natura nascentes*), the natives call them *Batatas* [accus. plural], which when I saw I thought to be rapes of Lombardy [? 'Insubres napos'] or great earth-tubers [*Cyclamen Europæum? Rapum terræ* and *Tuber terræ* of the old botanists]. In whatever way they are cooked, roasted or boiled, they yield in delicate sweetness,* to no confectionery or other eatable whatsoever." They are, he adds, "*also* planted and cultivated in gardens." In his 3d Decade (lib. 4, p. 240) he mentions "maize, yucca, *ages* and *battatæ*," as plants that grew in Honduras when Columbus landed on that coast in 1502; and in the same Decade (lib. 5, p. 261), he names the same four plants as the ordinary food of the people of Caramaira (east of Darien) "as of the others," and again takes occasion to name the battatas, as surpassing all else "mirâ quâdam dulci mollitie—especially if one falls on the better sort (nobiliores) of them."

Oviedo gives a good description of the *Batata*, which, when he wrote (1525–35), was commonly cultivated by the Indians in Hispaniola and elsewhere, and highly prized (*Hist. gen.*, lib. vii, c. 4). It resembles the *Ajes*, he says, in appearance, but tastes better and is far more delicate. The leaf is more notched (*harpada*) than that of the *Age*, in nearly the same fashion. Some varieties are better than others, and he gives the names of the five kinds which are most highly esteemed. [Peter Martyr (dec. iii, lib. 9, p. 302) included the same five names among the nine varieties of *Ajes* that he mentioned as distinct; but in this, as in other matters pertaining to natural history, Oviedo is the better authority.] "When the *Batatas* are well cured,

* The sweet potato was an inspiration to Peter Martyr, who rarely indulged himself in such a flight as "dulcorata mollities."

they have often been carried to Spain, when the ships happened to make a quick passage, but more often they are lost on the voyage. Yet," adds Oviedo, "*I have carried them* from this city of Saint Domingo in Hispaniola, *to the city of Avila*," in Old Castile.

The "Gentleman of Elvas" who wrote the "True Relation" of DeSoto's expedition to Florida, in 1538, mentions *Batatas*, then growing in the Island of Terceira (belonging to Portugal).

Cieça de Leon, who was in Peru in 1547, speaking of the fertility of the valleys near the Pacific coast, and the plants cultivated by the Indians, names among these, sweet potatoes (Chron. del Peru, c. 66). In the Quichuan language they were called *apichu;* in the dialect of Quito, *cumar*. Mr. Markham, in a note to his translation (Hakluyt Soc., 1864, p. 234) mentions, on the authority of Dr. Seemann, "the curious and interesting fact that *kumara* is also the word for sweet potato in Tahiti, the Fiji Islands, and New Zealand." Garcilasso says these roots "which the Spaniards call *batatas* and the Indians of Peru *apichu*," are of four or five different colors, etc. "The *least good* are those that have been *brought from Spain*."

Jean de Lery found them in Brazil in 1557, and described them under their Tupi name—*Hetich*, as he wrote it—of which "the soil of Brazil is as prolific as that of Limousin or Savoy is of rapes." He describes the Indian method of planting; yet, "since these roots are the principal article of food of this country, and are met with by travelers in various places, I judge that *they grow spontaneously*" (Hist. Navig. in Brasil, p. 165). Montoya (Tesoro, 1639) gives the Tupi-Guarani name, *Yetĭ*, and mentions numerous varieties.*

Monardes, in the third part of his Simpl. Medic. ex Novo Orbe, published in 1574 (translated by Clusius, ed. 1593, p. 439) states that *Battatæ* "are now *so common in Spain*, that ten or twelve caravel loads are sent annually from Velez-Malaga to Seville."

DeCandolle (who has elsewhere printed a short article upon the subject) calls attention to the fact, which ought to be familiar, that sweet potatoes are roots, not tubers, and that Turpin long ago published good figures illustrating this; also that while these roots are free from acrid or noxious qualities, all the Convolvulaceæ with tubers, of which there are many, and not a few of large size, are inedible and acrid,—mostly as we know, violently purgative.

Manihot utilissima, Manioc, Cassava-plant.—DeCandolle assigns good reasons for concluding (as did Robert Brown, without giving his reasons) that this important food-plant of the

* Hans Stade, who was a captive in Eastern Brazil in 1549, briefly mentions these "roots called *Jettiki*, of pleasant taste." (Captivity, Hakl. Soc. ed., p. 166.)

tropics is American, not African. But he leaves unnoticed the convincing fact that *Manioc* and *Manihot* are Brazilian names, slightly corrupted, of a plant cultivated in St. Domingo and Cuba before the landing of Columbus, and which became known to Spanish and Portuguese discoverers before 1500, by its Haytian name, *yuca*, or *hiucca*.

Peter Martyr (1493) describing the food of the islanders, names "*Iucca*, from which they make bread" (Dec. i, lib. 1, p. 7; ed. 1574); in the third book of his second decade (p. 148) he mentions "*Iucca*, *Ajes* and *Maiz*, as the three plants used by the natives for bread; in the third decade (lib. 5, p. 262) he describes the mode of propagation by cuttings, of cultivation, and of the preparation of "Cazabbi" from the root: and he states that "there are many kinds of *iucca*" (p. 263). Oviedo (*Hist. Gen. y Nat.*, lib. 7, c. 2) describes "the bread of the Indians that is called *caçabi*," which is "made from a plant they call *yuca*," and he distinguishes two species of the plant. Acosta (*Hist. of the Indies*, transl. by E. G.; Hakluyt Soc. ed., p. 232), 1588–90, gave a good account of the plant *yuca*, and the kind of bread made from it, called *caçavi*.

Peter Martyr (Dec. iii, lib. 9, p. 301) relates the Haytian tradition of the origin of the cultivation of *yuca* in their island. "They say that a *Boitius* [i. e. *magus*, or diviner], a wise old man, after the lapse of many years, saw, on the banks of a river, a plant that was like a cane; pulling it from the earth, he made this wild plant a cultivated one. He who first ate the *Iucca* raw, quickly died. But because its taste was sweet, they determined that a way of using it should be diligently sought for. When roasted or boiled, it was less hurtful. At last they came to the knowledge of the latent poison in its juice," etc.

Gomara (*Hist. gen.*, c. 71), Acosta (*Hist. nat. y moral de las Indias*, 1588–90; lib. 4, c. 17), Monardes (*De Simplicibus medic.*, transl. by L'Ecluse, 1593, p. 437), and other writers of the 16th century gave good descriptions of the plant *yuca*, and of the *caçavi* or *cazabi* prepared from the root. By the blunder of European editors, in the last half of the 16th century, the Haytian name was transferred from the plant to which it belonged to one of another order, the *Yucca* of Linnæus and of modern botany. The mistake was pointed out by Lobel.

Jean de Lery (*Hist. Navig. in Brasil.*, c. 9) describes the two species that were cultivated in Brazil in 1557—under their Tupi names, *Aypi* [*M. aypi* Pohl] and *Maniot* [*M. utilissima*]. Marcgrav (*Hist. plant. Bras.*, p. 65) mentions many varieties of both species, and gives *Mandioca* as the name of the root, *Manduiba* or *Maniiba* for the plant. Of the products of the root, Cassava retains its Haytian name (*caçavi*) nearly; Tapioca is a corruption of the Brazilian (Tupi) *tipioca* or *tipiocui*.

Dioscorea sativa, alata, etc. *Yam.*—DeCandolle informs us that these species, or their allies, are wholly unknown to botanists in a wild state; that, although cultivated in the East Indies, they have no Sanscrit names; that they seem not to have been widely cultivated in Africa, but that the authors of the 17th and 18th centuries speak of them as widely diffused over the South Pacific islands, from Tahiti to New Caledonia and the Moluccas. In the summary they are assigned to Southern Asia (Malabar? Ceylon? Java?), and to the eastern Asiatic archipelago. Although a large part of the genus is indigenous to tropical America, it is thought that the cultivated species were probably introduced from the Old World. The following presentation of the evidence, as concerns America, may set the question in a different light:

The natives of Cuba and St. Domingo, when Columbus discovered those islands, cultivated two kinds of plants, for their roots. These were called, in the language of the islanders of St. Domingo, *Ages* or *Ajes*, and *Yuca*. Neither of these plants was known to the Spaniards. About *Yuca* there is no question; it was the *Manihot*, or Manioc, of which we have already discoursed. It is nearly as certain that the *Ages* was a species of *Dioscorea*, to which, in their ignorance of the language of the islands, the Spaniards at first gave the name of *Ñame*, *Niame*, *Igname*, *Inhame*, or other corruptions of a foreign (probably African), name; and this name seems to have been occasionally misapplied both to the *Yuca* and the *Batata*.

L'Ecluse, who had traveled in the south of Spain and in Portugal, in 1563, says that the *Colocasia* (*C. antiquorum*) "first brought from Africa, was common in many places in Portugal, near streams of water, that it was sought for by negro slaves in Portugal, who ate it both raw and cooked," and that it was "called by the Portuguese, following the Moors, *Inhame*,—by the Andalusians, *Alcolcaz*," etc. (*Rarior. Stirpium Hist.*, p. 299.) In a note to his translation of Garcia ab Horto (1574, p. 217), he says that "the plant called *Inhame* by the Portuguese has very broad leaves, and grows near the water, or in water,—not spontaneously, but when once planted it propagates itself from the roots," etc.

Some of the companions of Columbus had seen the *Inhame* (or *Ñame*) in Africa, and were ready to transfer its name to the first cultivated roots they saw in America. A few days after the discovery of Cuba (Nov. 4, 1492), Columbus saw fertile fields "full of *mames* ['these are *ajes* or *batatas*,' notes Las Casas], which are like carrots (zanahorias), and other plants, including kidney-beans and beans (faxones y fabas) much unlike ours." (Navarrete, *Colec.*, i. 200.) These *mames* are mentioned again, Nov. 6 (*id.*, 203)—in both places, probably by

an error of the copyist, for *niames;* for, the next month, some natives of Hispaniola brought "bread of *niames*, which are roots that grow as large as rapes (rábanos) which they plant and cultivate in all their fields, and on which they live; and they make bread of them, boil them, and roast them; and they have the taste of chestnuts, and no one eating them would believe they were not chestnuts" (*id.*, 238). A few days later, the Spaniards learned the name of these roots—or of others with which they were at first confounded. The Admiral sent a present to a friendly cacique. The officer who carried it reported, on his return, that "all this island (St. Domingo) and Tortuga are cultivated like the country about Cordova. The lands are planted with *Ajes*—which are little shoots (ramillos) that are planted, and at the bottom of each grow roots like *zanahorias*, which they use for bread," and these roots "are very savoury, and taste like chestnuts." "They have them here larger and better than he had seen in any place; for, he said, he had [seen] such also *in Guinea*" (*id.*, p. 242). Again, the natives "brought bread made of *niames*, which *they* call *Ajes*" (*id.*, 251); and, Dec. 26, they gave the Admiral a "collation, of *two or three kinds* of *Ajes*, and of their bread that they call *cazavi*," etc. (*id.*, 263). After this the name of *niames* gives place to *ajes* (or *ages*). On the second voyage of Columbus, the natives, near Isabella (in St. Domingo), brought great quantities of "*ages* which are like rapes (nabos) very excellent eating," and "this *aye*, the natives of Caribi (the Caribbean Islands) call *nabi*, and the Indians [of Hispaniola?] *hage*" (*id.*, 368, 369).

In two or three of the passages to which reference has been made—particularly those in which bread is mentioned—the Spaniards seem to have confounded the *ages* with the product of the *yuca* (Manihot) or to have included both under the general name of *niame* (or its equivalents, *Ñame*, *Igname*, etc). Amerigo Vespucci—or some one of the several translators through whom the relation of his first voyage comes to us—says, that in 1497, "the common food of the natives of Paria was the root of a certain tree (arborea radix quædam), which they reduce to a good enough flour, and that some call this root *Iucha*, others *Cambi*, but others *Ignami*" (Navarrete, *Colec.*, iii, 216).*

This confusion of names, in the first decade of discovery in America, was natural and unavoidable. The foreign name, *niame*, *igname*, was applied without much discrimination to roots cultivated by the natives of the islands and the mainland

* It is to this passage that Humboldt refers, in Nouv. Esp., 2d ed., ii, 468 (cited by M. DeCandolle, p. 63), as evidence that the name *Igname* was heard on the continent of America, by Vespucci, in 1497; but, as will be seen, Vespucci (or his copyist) does not say that this name was used by the *natives*.

—primarily, to *ajes*, occasionally to *yuca* (Manihot), and perhaps to *batatas*. In the relations of the voyages of Columbus only *two* cultivated roots are named—*Ages* and *Yuca*. The first book of Peter Martyr's first decade (dated 1493, but probably revised before its publication in 1511), names only these two; and in the third book of his second decade he mentions the use of the same two roots by the natives of Comagra, in Darien (p. 148); but in a subsequent chapter (dec. ii, c. 9., p. 191), he adds—as has been mentioned in a preceding note—a *third* kind of roots, which the natives of the province of Darien call *Batatas*, that grow in their country spontaneously. From this date to the middle of the 16th century the distinction between these roots, though occasionally lost sight of, is generally observed. Oviedo (*Hist. Gen.*, l. vii, cc. 2, 3, 4; p. 268–73), describes the *caçabi* and two species of the plant (*yuca*) that yields it; *ajes*; and *batatas*. The *ajes*, he says, were cultivated in Hispaniola, and in all the other islands, and on the continent; they were of various colors—white, reddish, inclining to mulberry, and tawny, but all white within, for the most part; the stem of the plant extends itself like that of correhuela (*Convolvulus* or Bindweed), but stouter; the leaves cover the ground, and are shaped much like correhuela and nearly like ivy or panela, with some delicate veins (unas venas delgadas), and the little stems (astilejos), on which the leaves hang, are long and slender, etc. The leaf of the *Batata*, he says (p. 274), is more toothed or notched (*harpada*) than that of the *Aje*, but of nearly the same fashion; and the two plants are much alike, but the *Batatas* are sweeter and more delicate, etc.: some of the *Ajes* weigh four pounds each, or more. In some parts of Castilla del Oro (in Darien), there are *Ajes* that are small and yellow, etc. (p. 273). His description of the two plants permits no reasonable doubt that his *Ajes* were of the genus *Dioscorea*. Moreover, they were not identical with—though they resembled—the imported *ñame* or "yam:" for Oveido states (*Hist. Gen.*, lib. vii, c. 19, p. 286), "that *name* (called *nnames*), is a foreign fruit, not natural to these Indies, which has been brought to Hispaniola and other places, and is suited to this evil race of negroes, and a profitable and good subsistence for them. . . . . These *nnames* seem to be *ajes*, but are not the same, and generally are larger than *ajes*." They had already multiplied greatly in the islands and on the mainland.

The distinction between *Ajes* and *Batatas*, though clearly apprehended, was sometimes lost sight of. Peter Martyr (dec. iii, lib. 9, p. 302), says that "the species of *Ages* are innumerable—the varieties being distinguished by their leaves and flowers;" and he gives the American names of nine of the

varieties; but five of these nine are named by Oviedo (p. 274), as varieties of *Batatas*. [See *Batatas*, ante.]

The "Gentleman of Elvas," who wrote the narrative of DeSoto's expedition, mentions a fruit, at Santiago, Cuba, called *batata*, the subsistence of a multitude of people, principally slaves, and which now (1538) grows in the island of Terceira, belonging to Portugal. . . . . It looks like the *ynhame*, with nearly the taste of chestnuts" (*Relaçam Verdadeira*, ch. 5).*

Jean de Lery, who was in Brazil in 1557, though he gives a good description of the *Batata*, does not mention the Yam; but it is figured and described by Piso (*Hist. Nat. Brazil*, 1648, p. 93), as *Inhame* of *St. Thomas*, called *Cara* by the natives of Brazil, and *Quiquoaquecongo* by the Congo negroes. Ruiz de Montoya has the name *Cará* in his Tupi dictionary, 1639, and mentions five varieties. As the Tupi name for the Virginia potato (Solanum tuberosum) *Carati* (i. e., white yam), is formed from that of the Inhame, it would seem that the latter was of earlier introduction. So, in the Mpongwe—a language of the Congo group—the potato is called *mongotanga* 'white-man's yam.'

Portulaca oleracea, *Purslain.*—Botanists have taken it for granted that this weed of gardens and other cultivated grounds was transported to America from the Old World. But Nuttall found it apparently indigenous on the upper Missouri forty years ago, and Dr. James in Long's Expedition, along the eastern base of the Rocky Mountains in what is now the State of Colorado. From thence to Texas it grows wild along with two other nearly related species. Moreover the following evidence tends to show that its introduction, if introduced by human agency, took place before the landing of Columbus.

On their first sight of the new world, the Spaniards were much impressed by the strangeness of all forms of animal and vegetable life: "all the trees are as unlike ours, as day is to night"—wrote Columbus, Oct. 17th, 1492, six days after landing at San Salvador: "and so are the fruits, and so the plants, and the stones, and all things" (Navarrete, i, 183). On the 28th, on the north shore of Cuba, he saw—apparently for the first time—a familiar plant: "*halló verdolagas* muchas y bledos," —he found much *purslane* and *bletum* (*id.* 192). It seems hardly possible that the Admiral and his companions could mistake a strange plant for a salad herb so well known as "verdolagas" to Spanish eyes and palates. Again, Oviedo, writing about 1526, in a list of "plants in the island of Hispaniola which are like those of Spain, and which were before

* In one Indian language of the south, the Choctaw, the sweet potato is now called *ahe*; while the Virginia potato (S. tuberosum), takes the adopted prefix of "Irish," *Ilish ahe*, or is sometimes called *ahe lumbo* 'round *ahe*.'

the Christians came to these parts, and are natives of this land, and were not brought from Spain," names "verdolagas or *pertulaca*" and "bledos or *bletum*" (*Blitum*).

In his description of "perebeneçuc," written in 1525, he says, that plant grew, in great abundance, in Saint Domingo and in many places on the continent, in the woods and fields; even "purslane (*verdolagas*) is not more abundant here" (*id.*, lib. xi, c. 5, p. 378.)

Jean de Lery, in Brazil in 1557, was as much impressed by the novelty of the flora, as Columbus had been, in the West Indies. "I declare," he wrote (*Hist. Navig. Brasil.*, 168), "as far as it was permitted me to discover in wanderings through the woods and fields, that there are no trees or plants, or any fruits, that are not unlike ours, these three excepted, *portulaca*, ocymum and filex" (in the original French edition, 1578, p. 217, "*pourpier*, basilic, et fougière.").

Capt. John Smith, in Virginia in 1606, found "many herbes in the spring, commonly dispersed throughout the woods, good for broths and sallets, as Violets, *Purslain*, Sorrell, etc.; besides many we used whose names we know not" (Smith's *Gen. History*, 1632, p. 26; and repeated by Strachey, *Travaile into Virginia*, p. 120). Smith's *purslain* was probably *Sedum ternatum.*

Sagard-Theodat, in the relation of his *Grand Voyage du Pays des Hurons*, in 1624 (p. 331), says that the Hurons make little use of herbs, "although the *pourpier* or *pourcelaine* is very common there, and grows spontaneously in their fields of corn and pumpkins."

W. Wood, who was in New England from 1629 to 1633, names "Purselane" among plants growing "in the woods, without either the art or the help of man" (*N. E. Prospect*, pt. 1, c. 5). We doubt its growing literally in the woods, as unlike its natural habit, and place more confidence in the statement of Champlain, who, in his earlier voyages, 1604–11, found plenty of excellent *pourpier*, for his salads, on the coast of New England, growing among the Indian corn; "the savages making no more account of it than if it were a noxious weed" (*Voyages*, ed. 1632, p. 80).

Humulus Lupulus, Hops.—Although the matter has nothing to do with the introduction of hops into cultivation, it is noticeable that DeCandolle assigns the home of the plant only to Europe and Western Asia. It is undoubtedly indigenous to North America also, and is mentioned as such in the American works. In Gray's Manual, besides the printing of the name in the type appropriate to indigenous species, the plant is expressly stated to be "clearly indigenous." But, through some oversight, in the Prodromus (xvi, 29), it is stated, in connection with this very reference, that the plant was introduced.

Oca.—Considering that *Maté* and *Coca* find place in this volume, although perhaps rather employed than cultivated (at least the former), the absence of *Oca* (*Oxalis tuberosa* and *O. crenata*) is noticeable. This esculent root deserves mention, if only for the antiquity of its culture in Peru. The name, which is Quichuan, appears to have belonged, specially, to *Oxalis tuberosa*. Another root "like the *oca* in shape, but not in taste," called in Quichua *añus*, was less esteemed. Both were cultivated in Peru in the time of the Incas, and in the districts where no maize grew, the crop of these tubers was of much importance (Garcillaso, *Comment.*, b. v, c. 1; b. viii, c. 10.) J. de Acosta, 1588–90, says "there are an infinite number" of roots used for food in the Indies, "but the *Papas* (potatoes) and *Ocas* be the chief for nourishment and substance" (*Nat. and Moral Hist. of the Indies*, lib. iv, c. 18).

Our notes upon plants cultivated for their herbage, tubers, roots, etc., have run to such a length, that the remainder, concerning some plants cultivated for their fruits and seeds, must be left for another article.

ART. XXVIII.—*Remarks on Glyptocrinus and Reteocrinus, two Genera of Silurian Crinoids;* by CHARLES WACHSMUTH and FRANK SPRINGER.

IN the second part of our Revision of the Palæocrinoidea, at page 185, and following, we undertook to define the character and relations of *Glyptocrinus* and allied genera, in such a manner as to render it possible to group the species thereunder with some approach to their natural order. As is well known to every one who has attempted to identify the species, the American Silurian Crinoids are an extremely difficult group to understand. There are a few well marked species, of which ample collections have been made in Ohio and Indiana, but a large number of species have been described by Billings, Hall and others, from very meagre and imperfect material. Of many of these forms specimens are exceedingly rare, and we are often obliged to rely upon illustrations which are unsatisfactory, and descriptions which are necessarily defective in the delineation of specific and even generic characteristics. Under these circumstances it was scarcely to be expected that our conclusions would prove entirely satisfactory, even to ourselves.

Our treatment of the genera *Glyptocrinus* and *Reteocrinus* has been somewhat sharply criticized by Mr. S. A. Miller, in the Journal of the Cincinnati Society of Natural History for April, 1882, in connection with the description of some new species un-

der the first name. He objects to our definition of the characters of the former, to our rectification of the latter, and to our reference of species thereto. He also intimates that we have taken unwarrantable liberties with Billings' genus, and been guilty of a lack of proper respect for the work of its founder.

We have given to the remarks of Mr. Miller the consideration that is due to the observations of a gentleman of acknowledged learning, and whose researches in the literature of this branch of Natural Science have lightened the labors, and merited the thanks of every American Paleontologist; and have reviewed the species referred to the two genera in question with the aid of somewhat better material, as to some of them, than was at our command before.

With regard to *Glyptocrinus*, Mr. Miller states that we "seem to have been practically unacquainted with the genus;" in support of which he instances the fact, that our diagnosis requires that the surface of the plates should be "ornamented with radiating striæ in the form of elevated ridges, which divide into numerous triangular, impressed areæ;" that the basals should "scarcely extend to the sides of the body;" that the second radials should be "hexagonal," the third radials "pentagonal," and that there should be "twenty arms."

It is true that we have in our diagnosis ascribed these characters to the typical form of the genus, but in singling them out as the essential characters by which we define the genus and separate it from others, Mr. Miller is either somewhat uncandid, or else he has overlooked our distinct statement, under the head of *Glyptocrinus* on pages 186 and 187, of the characters by which it is separated from *Glyptaster* on the one hand, and *Reteocrinus* on the other. When we began the systematic investigation of this group, we found an assemblage of species referred to the above named genera, in such a manner as to render the recognition of generic limits impossible. This was especially the case with *Glyptaster* and *Glyptocrinus*. After much perplexing study we recognized the three types, into which these species might be grouped somewhat more satisfactorily than before; one of which was represented by the two species described by Billings as *Reteocrinus*, but with a misconception of their true characters.

It may probably be said with justice, that in this case, as perhaps in some others, we have adhered in our diagnosis of generic characters rather closely to the particular form which we regard as typical, and have not in express terms indicated the limits to which variations of these characters may and do extend. That modifications of characters and departures from the typical form in various directions are to be expected within the limits of every genus, is a fact which we have always

admitted and repeatedly asserted. We do not know of a single genus, illustrated by any considerable number of specimens, in which there are not some forms exhibiting a variation of one or more of the typical characters, and constituting transitional forms between that and some allied genus. The same may be said of some of the best defined species, and indeed, this observation may be extended to almost every group, whatever be its rank, which naturalists have attempted to separate and define. For example, one of the best characters of *Actinocrinus* is the simplicity of the arms, which almost universally remain undivided after becoming free. Yet we find in one of the latest species, *A. Lowei*, which otherwise retains and exaggerates all the characteristic features of the genus, that some of the arms in each ray bifurcate beyond the body; and isolated specimens of other species have been found in which such a bifurcation occurs in one or two arms out of the whole number.

No method of systematic classification has as yet been devised to adequately provide for all such cases; and we do not believe it possible so to limit and define the characters of a genus, as to escape the difficulties arising from modifications due to individual growth, and the variations of types in geological time.

A modification of the phraseology of our generic descriptions of *Glyptocrinus* and *Reteocrinus*, by which the existence of certain of the less important characters, such as surface ornamentation, the number of arms, and the geometric form of plates should be stated in less absolute terms, and with greater allowance for exceptional cases, would apparently meet the objections urged by Mr. Miller on this point; and we may find it advisable to make such alterations hereafter in this and perhaps other cases. It did not occur to us that our language was liable to misconception in this respect, in view of our frequent expressions as to the value of such characters, and our explicit statement of the leading characters. We do not regard the number of arms, for instance, as an absolute specific distinction, much less generic, although it is often an *important* character in connection with others, and a useful guide to the recognition of types; but departures from the prevailing rule are of frequent occurrence in genera, species, and even in the different rays of the same individual. This fact we have time and again pointed out in our writings. (See Rev. II, pp. 40 to 50 and other places; Transition forms in Crinoids, Proc. Philad. Acad. 1878, p. 224 et seq.) These considerations, however, and any modifications we might make in our language to avoid further misunderstanding, would not in the least affect the validity of the separation of the two genera *Glyptocrinus* and *Reteocrinus*

as we have defined them, or the reference of species thereto, in any substantial respect.

Mr. Miller expresses the opinion that our "separation of the species under this genus *Reteocrinus* and that of *Glyptocrinus*, shows to one familiar with the structure such a cross mixture of character as to indicate a want of general acquaintance with the genera and species," and after referring to Billings' statement of the generic characters of *Reteocrinus*, he asserts that "up to this time no Crinoid possessing the characters ascribed to this genus has been found in the Hudson River group of this locality" (Cincinnati).

We freely admit the great advantage which flows from an intimate familiarity with the fossils at the locality from which they are derived. An accurate knowledge of the mode of occurrence and distribution of the respective species, and their association with other fossils, such as can only be gained by the collector himself, furnishes an aid to the interpretation of their systematic relations, whose importance cannot be underestimated. For this reason, upon questions relating to these genera, we attach much weight to the opinions of our Cincinnati friends, who not only are themselves collectors as well as investigators, but have access to the other numerous fine collections that have been made in that locality; and we are gratified to be able to avail ourselves of the benefit of their observations, whether critical or otherwise. In a work of the nature of ours, so beset with difficult problems in classification, we do not expect to be exempt from error and shall be only glad if others are led to the investigation of these questions independently, because we are sure that by the operation of different minds, considering the subject from other points of view, and with other material than ours, a nearer approach to correct results will be gained.

When it appears, however, that the two leading naturalists of Cincinnati, after such critical study of the subject as is necessary to enable them to describe new specific forms, have reached conclusions diametrically opposite with regard to the characters and relations of *Reteocrinus* and *Glyptocrinus*, we may perhaps be warranted in attaching somewhat more importance to the results of our own studies, which we can see no reason to think less reliable, in any material respect, on account of any thing that has been thus far advanced against them.

Prof. Wetherby, in connection with the description of his interesting species *Reteocrinus* (*Glyptocr.*) *Richardsoni* (Journ. Cin. Soc. Nat. Hist. 1880, vol. ii, Pl. 16) observes, that the different species of *Glyptocrinus* found in the Cincinnati group "naturally fall into two groups, the extremes being represented by *Gl. decadactylus* and *Gl. Nealli*;" that "these two groups are

closely united by a series of intermediate forms, of which the *Gl. Richardsoni* is the last and most important link;" and also that "the *Gl. Nealli* . . . . seems to be as closely allied to *Reteocrinus* of Billings as to *Glyptocrinus*." Afterward, in the April, 1881, number of the same Journal, Prof. Wetherby, with his new species *Reteocrinus gracilis* under consideration, makes the following statement, under the head of *Reteocrinus:* "Under this generic name, Mr. Billings described two species from the Trenton rocks of Canada, in the publication cited above. Like most of the fossils of the locality whence they were obtained, these were in a very poor state of preservation. Enough is shown, however, by Mr. Billings' figures to make it conclusive that several forms of our so-called *Glyptocrinus* should be referred to this genus. Among them I should place *Gl. Nealli* Hall, *Gl. Richardsoni* Wetherby, and the species of which the description is to follow" (*Reteocr. gracilis.*) This opinion of Wetherby was before us when preparing the second part of our Revision for the press, both in its published form, and more at length in private notes, and as he could scarcely be said to be "practically unacquainted with the genus," we naturally attached much importance to it as a confirmation of our own views.

Furthermore, Meek, in re-describing "*Gl. Nealli*" in the Paleontology of Ohio, vol. i, p. 34, and having before him at the time many of the finest Cincinnati collections, alluded to the characters of this species as "showing a decided approximation toward *Reteocrinus* of Billings."

These extracts will be sufficient to show that so far as authority, and the discoveries of the latest and most competent observers, could furnish a guide, we were fully warranted in referring *Gl. O'Nealli* and allied species to *Reteocrinus*. A consideration of what we have stated in our generic descriptions, and our repeated allusions to these two genera in the discussion of family relations, will also show that we made such reference after due deliberation and careful study, and for reasons still more conclusive than those stated by the above mentioned authors. We have considered *Glyptocrinus* a form of the utmost interest and importance, and have made it the foundation of our discussion of the family relations of the Actinocrinidæ and Rhodocrinidæ.

Let us now endeavor to ascertain what the *Reteocrinus* of Billings really is; and we wish to state in this connection, that we yield to none in admiration for the work done by E. Billings in fossil crinoids. He was continually embarrassed by the poverty of his material, and the wonder is not that he made mistakes, but that he made so few. His excellent judgment, keen discrimination and scientific methods, we have

reason to appreciate, not only from his published works, but from an extended correspondence with one of the writers during the preparation of his admirable articles on the structure of Crinoidea, Cystidea and Blastoidea, in 1869.

Billings established his genus *Reteocrinus* upon two species, *R. stellaris* and *R. fimbriatus*, which are described in Decade iv, of the Geol. Surv. of Canada, pp. 64 and 65, and illustrated on pl. ix, figs. 3, 4. Of *R. stellaris*, which he took for the type of the genus, he had four specimens, three of which were fragmentary, and all of them in such a poor state of preservation, that Billings himself says at the end of the description, that "none of the specimens collected are perfect, and the characters of the species, therefore, have not been fully ascertained." The interradial spaces were very deeply depressed and filled with a hard matrix of limestone, which concealed from view the whole interradial portion of the calyx, with the exception of some small stellate points, which are now known to be the projecting summits of the plates. His principal specimen, fig. 4*a*, was so imperfect that Billings seemed to think that the ridge-like series of anal plates on the azygous side might possibly be an arm, and that there might be six (primary) arms in the species, although the generic description calls for but five primary radials. He considered the plates following the first primary radials to constitute arms, and found that the right (left posterior) of these "arms" divided on the fourth joint, but the others he could not see distinctly. The genus, of which this was the best specimen of the typical species, he considered to have "no perfectly formed plates," and its cup to consist of a "reticulated skeleton, composed of rudimentary plates, each consisting of a central nucleus, from which radiate from three to five stout processes," (Dec. iv, p. 63), characters which do not exist, as subsequent investigation of the type specimen has fully demonstrated.

R. fimbriatus, the second species, was described from a single specimen, Dec. iv, pl. 9, fig. 3*a*, and this, as Billings states, is "very imperfect." There is enough, however, in his figure and description to show, that in the opinion of the founder of the genus, a species having a pentagonal column; the "basals" (underbasals of our terminology) minute; the "subradials" (basals) one line in height; the arms several times divided (but only once in the body); a bifurcation on the third primary radial; and the spaces between the rays "*filled with very small plates*," might properly be referred to *Reteocrinus*. These characters apply equally well, and with scarcely any variation, to the so-called *Glyptocrinus O'Nealli* Hall, *G. cognatus* Miller, *Gl. Bæri* Meek, and *Reteocrinus gracilis* Wetherby, and with the exception of the column, to *Gl. Richardsoni* Wetherby, *Gl.*

Pattersoni Miller, and *Gl. subglobosus* Meek, all from the Hudson River Group at or near Cincinnati; and this may be taken as a sufficient answer to Mr. Miller's statement, on page 13 of the author's edition of his paper before cited, of the essential characters of *Reteocrinus.*

In 1869, in a letter to one of the writers, Billings himself stated that *Glyptocrinus O'Nealli* was certainly not a *Glyptocrinus,* and indicated its probable relationship to *Reteocrinus.* Unfortunately we are unable to find his letter, or we should quote his exact language.

In order to obtain, if possible, some additional information as to the exact condition and character of the typical specimens of *Reteocrinus,* we applied to Mr. Walter R. Billings, of Ottawa, Canada, a nephew of E. Billings, and himself a very acute observer and ardent naturalist, and requested him to examine the original types deposited in the Museum of the Canadian Geological Survey, and advise us of the facts. This Mr. Billings has done, with an intelligence and care which merits the highest commendation, and a generous kindness for which he has our warmest thanks. We quote the following extract from his letter of July 10th, 1882:

"Your communication contains an uncleaned but very perfect specimen of *Glyptocrinus O'Nealli* Hall, (*Reteocrinus O'Nealli* of Wetherby, Wachsm. and Spr., and others) with a request that I compare it with the type specimen of *Reteocrinus* in the Canadian Survey Museum, and inform you as to the facts. Prof. Whiteaves, Palæontologist G. S. C., with his characteristic kindness, granted me full permission to examine the type specimens of *R. stellaris,* and I have given special attention to those figured in Decade iv, G. S. C., as 'figs. 4*a*, 4*d*.' Both these specimens are obscured by a hard adherent matrix, which in so valuable specimens would require a skilled lapidary to remove; however, with a soft brush and a little moisture, I readily removed small loose portions of shale, and made the determination of the leading points easy.

"The column is as originally described.

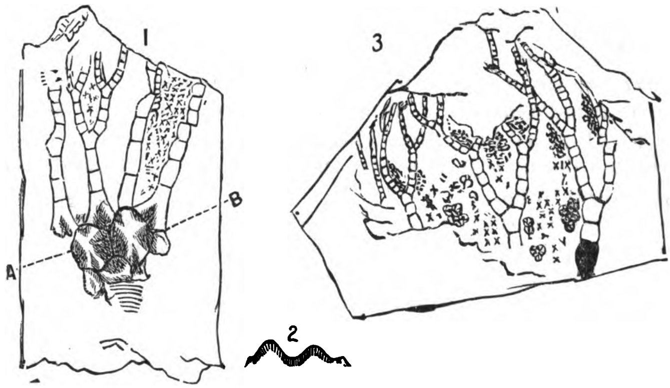
"In the specimen figured '4*d*,' I find a series of five (5) subequal plates, resting on the column, each bearing a bow-shaped ridge with sinus upward, not in contact with the margins, except where it meets corresponding ridges on the succeeding plates above; the remaining portions of these plates are depressed from ½ to ¾ of a line. The plates of the second order alternate with those of the first (two are tolerably well shown on the specimen 4*a*), and are heptagonal, resembling a hexagon slightly truncate, they have ridges corresponding with, and forming continuations of, those on the plates below, which meet in the center, and divide to become continuous with

ridges on the succeeding series of plates. The plate of the azygous side has three ridges passing upward; one from the center to become continuous with a ridge following the median part of the azygous interradius; the remaining two, which are directed obliquely, meet with similar ridges on the adjoining plates of the third order. The depressions between the ridges of the plates of the second order extend slightly to the plates of the first and third order; they are deep, especially the larger one at the azygous side, which has a depth of ¾ of a line. The plates of the third order, which alternate with those of the second, are radial in position, and support in an upward direction a row of other plates with strong, rounded, arm-like ridges, which in the specimen resemble closely arm plates, as which they were described by E. Billings. They are, however, evidently radials with elevated ridges, similar to the primary radials of *Gl. O'Nealli* Hall, which, like these, were connected laterally by interradial plates, and formed a part of the calyx. This is indicated by the numerous stellate pieces interspersed between the ridges, which in all probability represent interradial plates, of which only the elevated central portions are exposed to view, while their depressed margins are obscured by matrix. These stellate pieces are continued as high as the third plate of the secondary radials, and I have observed one within the axis of the first bifurcation to the left of the azygous series, thus indicating that the body in this species is not confined to the three lower angles of the plates, as suggested by E. Billings, but that it extended to the secondary radials.

"So far as the imperfection of the material will admit of comparison, there is a strong resemblance between *Reteocrinus stellaris* and *Glyptocrinus O'Nealli* Hall, which extends not only to the arrangement and form of first, second and third ranges of plates, but to the entire radial and interradial series, in view of which, and in the absence of any points of more than specific distinction, I am led to think the two forms congeneric.

"In addition to the two specimens on which these remarks have been founded, and to those figured in Pl. 9, Dec. iv, G. S. C., there is in the G. S. C. collection a flattened specimen, showing the side opposite to that shown in fig. 4*a* (loc. cit.), but wanting the first three ranges of plates, leaving the identity of the species not quite positive. This specimen (fig. 3, infra), has the interradial series more clearly and fully shown, and is filled with stellate pieces as high as the third secondary radials, below which they are interspersed with smaller and flatish plates, which grow smaller above, and disappear either lost in the matrix or through preservation. At one point at least, these small plates are seen to be continued with the arm pieces; they may represent the vault, and if so, this is another point of resemblance to *Gl. O'Nealli* Hall."

In addition to the above expressed details, Mr. Billings has furnished us drawings of the type specimen (fig. 4*a*), as it appears after being somewhat developed by cleaning, which shows that the three lower ranges of plates, instead of being "rudimentary," are perfectly formed, connected with each other by distinct sutures; much elevated in the middle and marked with strong radiating ridges, and having greatly flattened wing-like margins, which were before obscured by the matrix. He also figures the flattened specimen referred to in his letter, but not figured in the Canada Reports.



Reteocrinus Billings.

Fig. 1. Billings's type specimen (Geol. Rep. Can., Dec. iv, Pl. 9, fig. 4*a*). Fig. 2. Section A–B, to show depression of margins of plates. Fig. 3. Specimen in G. S. C. collection not figured before. All from drawings by Walter R. Billings.

We think that with these figures, and the notes above quoted, the question of the generic identity of *Gl. O'Nealli*, and allied forms with *Reteocrinus*, may be considered at rest.

By following the strict letter of the rules of nomenclature, we might have been justified in setting aside Billings' genus entirely, and re-describing the type under a new name, for the reason that the leading characters ascribed to it as generic, do not in fact exist in his own species or elsewhere. This has been partly done both by Zittel and De Loriol, neither of whom recognize *Reteocrinus* at all. But the true spirit and intent of the rules of scientific nomenclature do not require such a course. We consider it far more just to the original observer, who has called attention to a new generic type, to assign to it the true characters as disclosed by subsequent investigation, and retain the genus so modified as to include such forms as are naturally congeneric with the species first described, than to deprive him, by a technical adhesion to a strict rule, of all credit for his work, and burden science

unnecessarily with new names. If under these circumstances it happens, that the true characters of the group are better and more comprehensively expressed in some other species than the one first described, there is, in our opinion, not the least objection to adopting it as the type of the genus thus rectified. And where the original species is imperfectly known, this is the only rational thing to do, because we cannot well take, as the type of a genus, a species which is not itself accurately defined. The rules are intended to promote accuracy and clearness in scientific determinations. We do not believe they require absurdities, but if any of them does, the sooner it is abrogated the better.

Mr. Miller thinks that in making *Gl. O'Nealli* the type of *Reteocrinus*, we have been guilty of an "open violation of the rules of nomenclature." We think our practice in this respect fully justified by the consideration above stated. At all events we shall adhere to it, and we find that other good authorities do the same thing.

A few words now as to the relations of these two genera. At various places in Pt. II, of our Revision, for example pp. 7, 95, 183–187, we have alluded to the intimate relation which exists between the families Rhodocrinidæ, with two rings of plates below the radials, and Actinocrinidæ with but one. We have shown how *Glyptocrinus* with its rudimentary underbasals, and its interradial series, all above the line of the first radials, formed a connecting link between the two families, approaching the *Rhodocrinus* type in the first character, but in the second departing from all other genera of that family, and exhibiting an approach to some of the earlier forms of the Actinocrinidæ. Its close affinities with *Reteocrinus*, with which we stated (p. 183), it to be "connected by most remarkable transition forms," led us to refer *Glyptocrinus* to the Rhodocrinidæ, although there were almost as good reasons for referring it to the Actinocrinidæ. It might perhaps have been well to place it in a section by itself, on account of the exceptional disposition of its interradials.

It is an important fact that in all Actinocrinidæ, without a single exception, the regular interradial series rest upon the edges of the first radial plates, and are not extended down to the basi-radial suture. In the Rhodocrinidæ, the first interradial and anal plates all rest upon the basals, except in *Dimerocrinus*, *Glyptaster*, *Eucrinus*, *Lampterocrinus* and *Glyptocrinus*. In the first four of these genera, the anals rest upon the basals, though in *Dimerocrinus* the regular interradials sometimes barely touch them. *Glyptocrinus* is the only genus of the Rhodocrinidæ in which neither the anal nor interradial plates are in line with the first radials, or in contact with the

basals, and it is this character, as far as we can discover, which distinguishes it best of all from *Reteocrinus*, and upon which a few species of the type of *Gl. decadactylus* can be satisfactorily grouped. Of the species which we referred to *Glyptocrinus*, it will be observed that *Gl. fimbriatus*, *Gl. nobilis*, *Gl. Shafferi*, and *Gl. subglobosus* were mentioned as doubtful for reasons there stated, and had our printed copy corresponded with our original notes, *Gl. ramulosus* and *Gl. ornatus* would have been noted with like reserve, owing to the impossibility of accurately determining their characters from the specimens described. Of these we have become satisfied that *Gl. subglobosus* is a *Reteocrinus*, very closely related to *Gl. Bæri*, and *Gl. Shafferi* and its variety *germanus* are evidently immature specimens, as to whose generic characters we are unable to satisfy ourselves from the figures and descriptions. *Gl. ramulosus* is probably an *Archæocrinus.* In *Gl. ornatus* the figure shows the upper parts to be so obscured by the matrix, and the base to be so imperfect, that we cannot pass an opinion on it.

Of the remaining species, *Gl. angularis* is a departure from the typical form in the direction of *Glyptaster*, to which, or more likely to its subgenus *Eucrinus*, it might, perhaps, be advisable to refer it. *Gl. priscus* is a young *Glyptocrinus* with strong transitional characters toward *Reteocrinus.* The highly elevated connecting ridges on the larger plates are very similar to the so-called "processes" of Billings' *Reteocrinus stellaris*. *Gl. parvus* is apparently a young example of a typical *Glyptocrinus*, which therefore has the basals comparatively large, but as the anal side is unknown, it is not wholly free from doubt. Of *Gl. Fornshelli* we unfortunately have not the description. Miller's *Gl. Miamiensis*, Cincin. Journ., April, 1882, is apparently a *Glyptocrinus* with variation of characters toward *Reteocrinus.* The genus is therefore typified by *Gl. decadactylus*, *Gl. Dyeri*, Miller's new species *Gl. sculptus*, and probably *Gl. parvus*, whose characters are, as stated in our diagnosis, to wit: a sculptured surface; rudimentary underbasals; small basals; the interradial and anal spaces occupied by plates of definite arrangement, all located above the line of the first radials, and nearly equally distributed among all five rays; and twenty arms. And if we further state that the body plates are "generally" ornate, and that there are twenty arms "as a general rule," it will enable us, without offending against any requirement of critical accuracy, to bring within its limits those transitional species above mentioned, which seem to be nearest to its type. *Reteocrinus* is readily identified by its highly elevated radial ridges and depressed interradial spaces, filled with numerous small plates of irregular arrangement, and extending between the first radials down to the basals; by its under-

basals, often well developed; its strongly marked bilateral symmetry; and by its ten primary arms as a rule. It is typified by *Reteocrinus O'Nealli*, *R. cognatus*, *R. gracilis*, *R. stellaris*, *R. fimbriatus;* while *R. Richardsoni*, *R. Bæri*, *R. subglobosus* and *R. Pattersoni*—the latter described by Miller as a *Glyptocrinus*, Cincinn. Journ., July, 1882—are good examples of it in every respect, except that the underbasals have not as yet been noticed, and perhaps do not exist; although we think it very probable that they may be found to possess these plates in a more or less rudimentary form as in *Glyptocrinus*. We do not consider it necessary or advisable to separate these species from the typical form upon this character alone, since the whole assemblage of species above named forms a group, which is united by other well defined characters. The slight modification of our statement of generic characters renders it easy and natural to include them all.

In the Cincinnati Journal for April, 1881, Mr. Miller described two very interesting aberrant species from the Lower Silurian near Cincinnati. One of these, *Gl. Harrisi*, is a *Glyptocrinus* with a quadrangular column and, possibly, quadripartite base, and having the anal series, as we learn from the figures, extended down to the basals. If it has in fact four basals, it would be a good *Mariacrinus*, were it not for the position of the first anal plate, which is not in contact with the basals in any of the *Melocrinites;* or it would have the calycal structure of *Abacocrinus* without the other characters of that genus; showing thus a tendency toward the Actinocrinidæ. If on the other hand it has five basals, it would represent a variation from the *Glyptocrinus* type in the direction of the Glyptasterites, without however any development of underbasals. The other species for which Miller has established a new genus, *Xenocrinus*, has a quadrangular column and four basals; surface devoid of ornament; the radials highly elevated; interradial spaces deeply excavated and filled with a great number of small irregular plates; ten arms; bilateral symmetry; and no underbasals as yet observed. So far as we can judge from the figures (Journ. Cincinn. Soc., April, 1881, Pl. I, figs. 3*a*, 3*b*, 3*c*; and July, 1881, Pl. IV, fig. 6), all the interradial series rest upon the basals, although the description is silent as to this character. It is, therefore, a *Reteocrinus* with four basals, and represents a differentiation of the *Glyptocrinus* type toward the Rhodocrinoid form, with the basal characters of the *Melocrinites* section of the Actinocrinidæ. We think Miller was perfectly correct in referring it to a new genus, and in case the *Gl. Harrisi* should prove to possess a quadripartite base, and the discovery of other specimens shows this character to be constant, we should be disposed to adopt the same course with that form.

Mr. Miller considers it probable that *Gl. Harrisi* has five basals, because "in all other respects it agrees with *Glyptocrinus*"—not recognizing the difference in the disposition of the anal plates—but states that "if it possesses but four, it would not belong to *Xenocrinus*, but would still be very closely allied to *Glyptocrinus.*" We confess we are somewhat at a loss to understand just what Miller's views are, as to the limits of this genus. He objects to our reference of *Gl. O'Nealli* and allied species to *Reteocrinus*, and at one place considers the *Gl. O'Nealli* and his own *Gl. cognatus*, and therefore necessarily *Gl. Bæri*, to be true *Glyptocrinus.* At another, in describing his *Gl. Patersoni* (Journ. Cin. Soc., July, 1882), he states that the species differs from all other species of *Glyptocrinus* in having only ten arms. We can scarcely suppose that, when making this statement, he overlooked the fact that not only the *Gl. O'Nealli* and *Gl. Bæri*, but also *Gl. cognatus* which he had himself described a year previously, have but ten arms; but we infer that he then considered these species to be generically distinct from *Glyptocriuus.* If this be not so, how can it be said that *Xenocrinus priscillus*, which is in every respect a *Gl. Bæri* with four basals and a square column, would be generically distinct from *Gl. Harrisi?* Suppose each of them had five basals; would both be *Glyptocrinus?* Evidently not, according to Miller's reasoning above quoted; and if these two forms are generically distinct by reason of characters other than those at the base, surely *Gl. Bæri* and *Gl. decadactylus*, which differ in precisely the same way, must be.

A reinvestigation of the genera herein discussed, and their allies, has impressed us more than ever with the idea stated frequently in our Revision, that this little group of Lower Silurian Crinoids represents an embryonic type, from which both Rhodocrinidæ and Actinocrinidæ were developed. They are among the earliest forms we know, and they stand in a similar relation to these families that *Heterocrinus* and its allies hold to the Cyathocrinidæ. In both there is the same rudimentary and varying development of characters, which when fixed and constant, become of family importance. In both are found the types of the fundamental structure of the respective families in very simple forms, whose differentiations in various directions led to the several subdivisions and genera, into which these families have been divided. Within each there is found a commingling of characters which is a source of endless perplexity to those who are seeking to discover some clew to a natural classification. We are disposed to think that a further subdivision of the families, whereby these embryonic types should be placed in separate subfamily groups, would tend to eliminate some of the difficulties we have encountered,

and to this end we shall very probably hereafter propose to arrange in a distinct group the genera *Glyptocrinus*, *Archæocrinus*, *Reteocrinus*, *Xenocrinus*, *Glyptaster* and *Eucrinus*, and possibly one or two others, so as to constitute a subfamily, intermediate between the Actinocrinidæ and Rhodocrinidæ, and through which the latter are united to form the great family Sphæroidocrinidæ.

ART. XXIX.—*On the Smee Battery and Galvanic Polarization*; by WM. HALLOCK.*

1. INTRODUCTION.

THE electromotive force of the Smee battery, when determined with the greatest care by different methods, gives values which differ greatly from each other and are larger or smaller than the theoretically calculated value, E = 0·75 D.,† according as the resistance in the circuit used is larger or smaller than about 300 or 400 S. E.† It was with a view to obtaining an explanation of this fact if possible, and to obtain further data which might help to decide between various conflicting explanations already offered, especially those of Exner‡ and Fromme,§ that the first part of this research was undertaken.

The second part has to do with the question whether the electromotive force of galvanic polarization can be computed *a priori* from the thermal equivalents of the chemical reactions which take place thereby, and is intended to check the already determined values of this force and to obtain new ones in order to collect as large a number of values as possible, to see to what extent the experimentally determined values correspond with the theoretically calculated ones.

2. APPARATUS.

Not having at my disposal an electrometer which answered all the requirements of delicacy, damping, etc., it was determined to use a galvanometer with large resistances in the circuit. The instrument used was a Wiedemann reflecting galvanometer with a coil of 17,800 turns and a resistance of 6,700 S. E. The small ring magnet had a short time of vibration (1·1 second) and was so strongly damped that it came to rest

* Being an abbreviated translation by the author, the original having appeared in Wiedemann's Annalen, vol. xvi, p. 56, 1882.

† As this work originally appeared in Germany the Daniell (D.) and Siemens Unit (S. E.) were used.

‡ F. Exner, Wien. Ber., lxxx, 1879, und Wied. Ann., x, p. 265, 1880.

§ C. Fromme, Sep.-Abdr. a. d. 20, Ber. d. Oberh. Ges. f. Natur- u. Heilkunde. Wied. Ann., xii, p. 399, 1881.

in from 4 to 6 sec., even after a large deflection. It was so delicate that a single Daniell cell gave a deflection of 170 scale-divisions with the scale 2^m from the mirror and 330,000 S. E. in the circuit.

Inasmuch as resistance coils of the necessary length of wire would have been very expensive, and moreover, as it was interesting to know to what extent one can substitute liquid resistances for wire ones, where a certain degree of accuracy is needed, it was determined to try them in this research. The idea is not at all new and has often been applied; Hittorf* for example used a solution of iodide of cadmium between cadmium terminals; but as far as I know great importance has never been placed upon their accuracy or constancy. Exner† used a solution of $ZnSO_4$ between amalgamated zinc terminals, but one only need read the method in which his resistances were constructed and calculated to see that they can lay no claim whatever to accuracy.

The resistance used in this research was that offered by a column of a solution of $ZnSO_4$ in alcohol, 1^{mm} in diameter in section and 200^{mm} long; this capillary tube was horizontal and each end expanded into a vertical receiver 20^{mm} in diameter and 100^{mm} high, in which stood the amalgamated zinc terminals. A better form however is to simply invert a capillary U-tube into the two receivers as a siphon, since in the other form the precipitate which forms around the terminals falls into the capillary tube, thus reducing its section and increasing the resistance. An alcoholic solution was used because Kohlrausch‡ found that the specific resistance of such solutions was less influenced by slight impurities than in the case of the same salts dissolved in water. Care was taken to prove that the polarization of the terminals could be neglected, which was the case even when a very strong current was used (5 Bunsen cells through 40 S. E.). When afterward this resistance was compared with a wire coil of 200,000 S. E. there could be no difference detected in the results obtained. It moreover remained during the three months of its use constant to within the limits of an error caused by an error of 0·1° C. in the determination of its temperature. Of course the great objection to liquid resistances is their large heat coefficient (from 1·5 to 3·5 per cent for 1·0° C.). However there seems no reason why such resistances should not be used, where they can stand still in a case or water-bath and where about 0·2 to 0·5 per cent is sufficiently accurate. In all cases it is better to determine the resistance experimentally than to calculate it; the above

* W. Hittorf, Wied. Ann., vii, p. 563, 1879.
† F. Exner, Wien. Ber., lxxxiv, p. 528–529, 1881.
‡ F. Kohlrausch, Pogg. Ann. Ergbd., viii, p. 1, 1877.

resistance column was determined from time to time in the Wheatestone's bridge in the ratio 1,000 to 10,000. The resistance can of course be easily varied by varying the dimensions of the capillary tube or the amount of water and salt dissolved in the alcohol.

Objection might be made to the use of the galvanometer for such work, on the ground that the polarization would be diminished by the consumption of the gases by the current through the galvanometer, but a simple calculation will show that it would require a polarization equal to one and a half Daniell's to consume $0{\cdot}1^{cmm}$ of hydrogen per minute working in a circuit whose resistance was 150,000 S. E. That this quantity of gas may be neglected at first when the electrodes are still heavily coated is evident. This theoretical refutation of the above objection was strengthened by the following experiment. Two platinum plates were twice equally strongly polarized, and the first time connected through 150,000 S. E. and left and the curve of the diminution of the polarization plotted; the second time the similar circuit was only closed once a minute and only for from 6 to 8 sec. and then opened again, and the curve plotted in this case. The two curves showed that the consumption of gas by the current when left closed did not make itself apparent until after 17 min., i. e. it may be neglected for the first five minutes at least.

The electromoter possesses the advantage, that with the proper use of a switch or commutator it can be charged to a potential representing that electromotive force of polarization which is active *immediately* after opening the primary or polarizing circuit. It is, however, not as convenient for use, and necessarily has a long time of vibration and is weakly damped; a very convenient form of the switch is that made by Hartman in Würzburg, being a slight improvement upon the Weber quicksilver commutator.

3. On the Rise of the Electromotive Force of the Smee Battery.

Exner* endeavors to explain those values of the electromotive force of the Smee which fall above that calculated, from the thermal equivalents of its chemical reactions, $E=0{\cdot}75\,D$, on the ground that the acid contains oxygen in solution which oxidizes the hydrogen evolved, and thus increases the thermal equivalent of the battery.

This question could be easily answered if it were possible to get and keep a cell entirely free from dissolved gases. Exner used the method of short circuiting the cell for a long time, but

* F. Exner, Wien. Ber., lxxx, 1879 und Wied. Ann., x, p. 265, 1880.

it is evident that this method simply substitutes evolved hydrogen for any other gases which may happen to be dissolved in the acid, and it is just the hydrogen which it is necessary to remove, since to its presence is generally ascribed the diminution of the electromotive force below that obtained with the electrometer or by the compensation method (about 1·5 D).

In this research the following method was used to obtain a cell free from dissolved gases.

A strip of zinc 1×6^{cm} and a platinum wire $0·1^{cm}$ in diameter and 5^{cm} long, fastened in the cork of a 100^{cc} flask, constituted the cell used. Its force, when freshly filled with 5 per cent H_2SO_4, through a circuit of 150,000 S. E. was found E=1·07 D. It was then closed in a circuit of only 0·2 S. E. external resistance containing a tangent compass, and its force at the expiration of the first minute determined to E=0·71 D. after 20 min. to E=0·06 D. and after 70 min. to E=0·03 D. These small values, although they agree well with those obtained by Fromme,* can only be considered as approximations owing to the difficulty of accurately determining the internal resistance of inconstant cells. The cell was then left short-circuited for 20 hours in order to let the evolved hydrogen drive out the other gases as completely as possible; at the expiration of this time its force through a circuit of 150,000 S. E. was found quite constant E=0·69 D. In order now to drive out the hydrogen, the flask was placed over a burner and kept at a sharp boil for 20 min., the steam and gas passing off through a long narrow tube in the cork. A layer of petroleum about 1^{cm} deep was poured over the acid while boiling, to assist in keeping gases from redissolving in the acid. The flask was then sealed shut with hard wax and cooled. Its force 5 sec. after being closed in a circuit of 150,000 S. E. was found E=0·86 D. and after 15 sec. to be constant at E=0·70 D. An analysis showed that the liquid in the cell still contained 3 per cent free H_2SO_4. A repetition of the experiment gave the following more marked results.

The same cell was refilled and short-circuited for 18 hours, when its force in a circuit of 150,000 S. E. was found E=0·51 D. during the first minutes, it rose gradually, however, and became constant after six minutes at E=0·70 D. On being boiled and covered with petroleum and sealed as before, its force through 150,000 S. E. was found E=1·01 D., it sank, however, in 4 min. to E=0·88 D. in 25 min. to E=0·83 D., and in 2½ hours to E=0·73 D.

Thus it would seem that the value E=0·70 D. represents that force which is active when the liquid immediately around

* C. Fromme, l. c.

the platinum plate is saturated with hydrogen, and the evolution is just equal to the diffusion of the gas into the liquid.

This experiment would seem to show conclusively that the values above E=0·70 D. are not caused by any oxygen which may be dissolved in the acid.

A similar conclusion was reached in a series of experiments where the other gases were removed by leading CO_2 over the acid for a long time. It however appeared that it would cause a difference of as much as 10 per cent in the force of the cell according as the acid was saturated with air or CO_2, it being larger in the former case. Another series of experiments proved that the force of the Smee could be diminished by saturating the platinum plate with hydrogen without depriving the acid of its dissolved oxygen.*

All the above results are opposed to Exner's theory, that these larger values are due to the oxidation of the evolved hydrogen, and rather support the older theory that they are due to the small force of the hydrogen polarization which acts against the true force of the cell.

4. Experiments on the Fall of the Electromotive Force of the Smee Battery.

When the electromotive force of the Smee is measured in a circuit where the resistance is small in proportion to the size of the cell, i. e. when the density of the current on the platinum plate is large, values are obtained which fall decidedly below that of E=0·75 D.

Exner† says, this is due to the formation of $ZnSO_4$ in the cell which has a larger specific resistance than H_2SO_4, and that zinc is precipitated upon the platinum, thus increasing the internal resistance and diminishing the thermal equivalent of the cell.

To test this question a cell was constructed such that the zinc and platinum were in separate vessels connected by an inverted U-tube filled with 5 per cent H_2SO_4, the ends being tied up with parchment paper. The vessel containing the platinum was furnished with a lid so that CO_2 could be conducted through the vessel or it could be shut up air-tight. Owing to the large internal resistance of such a cell, it was not possible to get a very great density of current on the platinum, still its electromotive force fell as low as E=0·31 D. on being short-circuited, and rose again in a long circuit, even when the vessel containing the platinum was filled with CO_2, as high as E=0·92 D., and finally to E=1·07 D. An analysis proved that the liquid

* Compare also here C. Fromme, l. c.

† F. Exner, Wien. Ber., lxxx, 1879 und Wied. Ann., x, p. 265, 1880.

around the platinum did not contain a trace of $ZnSO_4$. It may be here remarked that had all the H_2SO_4 around the zinc become $ZnSO_4$, the consequent increase in the resistance of the cell, either in this case or that of the flask cell of § 3, it would have made a scarcely perceptible difference in the intensity of the current measured.

These results seem to throw us back upon the old explanation, which ascribes the variations in the electromotive force of the Smee battery, to the variations in the counteracting force of the hydrogen polarization of the platinum plate.

5. Determination of the Electromotive Force of Polarization.

The maximum value of this force can be arrived at in two ways, either by measuring it while the primary current is closed, or by plotting the curve of the fall of the force after opening the primary current, and from it deducing by exterpolation, the value for the instant of opening.

Exner* and Beetz† assume that the value obtained immediately after opening the primary current is practically this maximum value. Fromme,‡ on the contrary, says, "if one wishes to obtain the true maximum value, it is absolutely necessary to measure the polarization while the primary current is still closed." I must admit, from my experience, that values could only then be considered as approximating the maximum when they were determined *immediately* after opening the primary current, which it is scarcely possible to accomplish, unless perhaps with an electrometer and switch as before mentioned.

An example will show how rapidly the polarization vanishes. The following is the falling off of the polarization of 5 per cent H_2SO_4 between electrodes of gas-retort carbon.

Time in sec.,	0	2	10	20	30	45	60	120	180	480
Force in Daniell,	1·92	1·77	1·63	1·54	1·49	1·43	1·39	1·28	1·20	1·00

The value for "0" sec. is that calculated by closed primary current.§

Inasmuch as a galvanometer was used for the following determinations the method by closed primary current seemed decidedly preferable and was employed. Two difficulties however, arise when this method is applied. In the first place a

* F. Exner, Wien. Ber., lxxviii, 1878 und Wied. Ann., v, p. 388, 1878.

† W. Beetz, Wied. Ann., x, p. 348, 1880, u. Münch. Ber, p. 429, May, 1880.

‡ C. Fromme, Sep. Abdr. a. d. 20, Ber. der Oberh. Gesellsch. f. Natur. u. Heilk., u. Wied. Ann., xii, p. 399, 1881.

§ The vanishing of polarization has also been studied by Beetz and Witkowski, among others, whose results agree with mine; compare here W. Beetz (Pogg. Ann., lxxix, p. 106, 1850) and A. Witkowski (Wied. Ann., xi, p. 759, 1880.)

branch of the primary current goes to strengthen the current from the polarized voltameter through the galvanometer; in the second place a branch of the secondary current (from the polarized voltameter) goes backward through the primary circuit. That these two currents are weak enough to be neglected only under peculiar and rarely fulfilled conditions is evident as soon as we calculate their strength from the given forces and resistances. Call E the electromotive force of the polarizing (primary) battery and γ the resistance in the primary circuit exclusive of that in the voltameter which we will call w, let W be the resistance in the circuit of the galvanometer (150,000 S. E. or 330,000 S. E.); let further i be the intensity of current in the galvanometer, i' that in γ and i'' that in w and I, that when E is closed through $(\gamma+\mathrm{W})$ alone, i. e. $\mathrm{I}=\frac{\mathrm{E}}{(\gamma+\mathrm{W})}$. If now we call the force of polarization P, we have according to Ohm's laws

$$i=i'-i''; \ \mathrm{E}=i'\gamma+i\mathrm{W}; \ \mathrm{P}=-i''w+i\mathrm{W},$$

whence we obtain by substitution and transformation,

$$\mathrm{P}=\frac{\mathrm{W}+\gamma}{\gamma}.w.i-\mathrm{E}\frac{w}{\gamma}+i\mathrm{W} \text{ or } \mathrm{P}=(i-\mathrm{I})\frac{\mathrm{W}+\gamma}{\gamma}w+i\mathrm{W}.$$

If in this last equation we neglect $\gamma=100$ at the most, as added to $\mathrm{W}=330{,}000$, we have

$$\mathrm{P}=\mathrm{W}\left[i-\frac{w}{\gamma}(i-\mathrm{I})\right]. \qquad (1)$$

From (1) we see that only when $\frac{w}{\gamma}=0$ can we put $\mathrm{P}=\mathrm{W}.i$, which is very seldom the case, for γ rarely exceeds 5 or 6 S. E. and w varies between 0·3 and 5·0 S. E. I increased the resistance γ to 100 S. E. in order to make $\frac{w}{\gamma}$ smaller and more accurately determinable. All the values of polarization given below were calculated with formula (1).

Inasmuch as these experiments on polarization were undertaken with a view to testing whether we can *a priori* calculate the electromotive force of polarization from the thermal equivalent of the chemical reactions which take place thereby, some side experiments, more or less directly allied to this question, were made. For example, Exner* wishes to approximate the thermal equivalent of the compound $PtCl_4$ out of the difference in the polarization of HCl between platinum and between graphite electrodes, 1·26 D. and 1·60 D.; upon the supposition that all the evolved chlorine in the one case dissolved off platinum to $PtCl_4$. To prove the incorrectness of this supposition

* F. Exner, Wien. Ber., lxxviii, 1878, und Wied. Ann., vi, p. 353, 1879.

chlorine was evolved by a weak current upon a platinum plate until it should have dissolved off 0·176 grm. of platinum, the actual loss in weight of the plate was 0·00007 grm., i. e. there was none dissolved off at all. F. Kohlrausch had already obtained the same result in a similar experiment. In fact it is very difficult to explain the differences which almost always exist between the polarization of the same solution between platinum and between carbon electrodes, if we consider the electrodes as mere conductors, as Exner does, and do not admit that they become electrically excited.

Another experiment was made in which a current was found and measured between one platinum plate saturated with hydrogen and another free from all gases except CO_2, where the force was E=0·68 D. at first, but gradually fell off. There is no apparent thermo-chemical equivalent for this current and the only visible cause for it is the transfer of the hydrogen from the more to the less saturated plate. Beetz* has also shown the electromotive force of polarization between two platinum plates, when one is surrounded with hydrogen, even when the acid had been pumped and boiled out in the most careful manner possible.†

6. Values of the Electromotive Force of Polarization.

The results here obtained are arranged in the tables on the following pages.

In table I, the first column, "electrolyte," gives the solution employed; and the second, "per cent," the percentage of the salt in the solution. Under carbon and platinum are given the values of the polarization; "P," between "gas retort carbon," and bright platinum electrodes (simple surface 8^{sqcm}), where Δ gives the density‡ of the current upon the electrode, 1^{sqmm} taken as a unit, Δ is calculated from the formula $\Delta = \frac{E-P}{(w+\gamma) \, . \, S}$, where the letters have the same meaning as in formula (1) and S is the surface of the electrode, 800^{sqmm}. The values of "P," the polarization, are, in the cases where the primary current was closed, calculated by formula (1); these values are given under "3 Buns. closed" and "2 Buns. closed," the primary current being furnished by two or three Bunsen cells respectively. Under "open" are given the values determined after opening the primary current, the length of time elapsing until the read-

* W. Beetz, Wied. Ann., x, p. 348, 1880, u. Münch. Ber., p. 429, May, 1880.

† Compare here H. Helmholtz, Ber. Berl., p. 288, 1880; F. A. Flemming, Phil. Mag. V, i, p. 142, 1876; and Helmholtz and Root's, Pogg. Ann., clix, p. 416, 1876.

‡ I unfortunately followed previous examples and kept the electromotive force of the primary circuit constant; whereas it is evident that the only way to obtain results comparable with each other is to keep the density of current on the electrodes constant.

TABLE I.

Electrolyte.	%	Gas Retort Carbon. 3 Buns. closed. Δ	Gas Retort Carbon. 3 Buns. closed. P	Gas Retort Carbon. 2 Buns. closed. Δ	Gas Retort Carbon. 2 Buns. closed. P	Gas Retort Carbon. Open. Sec.	Gas Retort Carbon. Open. P	Platinum. 2 Buns. closed. Δ	Platinum. 2 Buns. closed. P	Platinum. Open. Sec.	Platinum. Open. P	Exner. Obs.	Exner. Calc.	Newly Calc.
		0·000		0·000				0·000						
H_2SO_4	5	43	2·02	20	1·92	2	1·76	29	1·95	5	1·67	1·42	1·43	1·36
HCl	6	--	----	26	1·54	2	1·45	44	1·33	5	1·16	1·60	1·61	1·57
NaCl	6	38	2·37	16	2·17	2	2·05	28	1·97	6	1·78	2·08	2·06	2·12
NaOH	5	43	1·93	22	1·79	4	1·63	--	----	--	----	----	----	1·36
$NaNO_3$	5	39	2·24	16	2·12	3	1·99	23	2·18	5	1·30	----	----	1·91‡
NaI	5	50	1·48	27	1·43	3	1·36	44	1·24	5	0·97	1·25	1·24	1·07
$Cu(NO_3)_2$	5	54	1·20	31	1·16	1	1·04	40	1·45	6	1·29	1·11	1·09	1·04‡
$CuSO_4$	5	53	1·20	30	1·18	4	1·06	41	1·34	5	0·88	1·13	1·15	1·12
$ZnCl_2$	10	44	1·92	20	1·89	2	1·84	31	1·86	8	1·82	----	----	2·25
$ZnSO_4$	9·8	41	2·07	18	1·99	2	1·90	21	2·26	4	1·88	2·14	2·14	2·12
$MnCl_2$	5	42	2·02*	20	1·91	--	----	30	1·91†	5	1·60	----	----	2·55‡
$MgSO_4$	5	37	2·32	19	1·91	3	1·68	18	2·39	3	1·62	----	----	2·00‡
$AgNO_3$	25	62	0·78	38	0·75	2	0·69	57	0·75	6	0·68	0·42	0·34	0·34‡
$Pb(NO_3)_2$	5	49	1.49	26	1·47	3	1·38	39	1·45	3	1·26†	----	----	1·36‡

* Sank in 20 min. to $P=1·88$. † The anode became covered with a brown film.
‡ Values uncertain because one does not know the secondary reactions.

TABLE II.

Substance of the Electrode.	Simple Surface. sq. cm.	H_2SO_4 5%.				HCl 6%.				NaCl 6%.			
		2 Buns. closed.		Open.		2 Buns. closed.		Open.		2 Buns. closed.		Open.	
		Δ	P	Sec.	P	Δ	P	Sec.	P	Δ	P	Sec.	P
		0·000				0·000				0·000			
Platinised platinum	28·6	--	--	6	1·57	09	1·13	5	1·12	06	1·80	2	1·77
Bright platinum	5·3	29	1·95	5	1·67	44	1·33	5	1·16	28	1·97	6	1·78
Gas retort carbon, used	28·0	--	--	5	1·53	--	--	10	1·38	--	--	5	2·05
Electric lamp points, used	2·0	--	--	5	1·48	--	--	7	1·45	--	--	10	2·02
		0·00	--	--	--	0·00	--	--	--	0·00	--	--	
Lead-pencil graphite	1·1	117	2·14	2	1·85	158	1·78	4	1·52	109	2·17	2	1·98
		0·000	--	--	--	0·000	--	--	--	0·000	--	--	--
Retort carbon, old	2·3	67	1·93	4	1·62	84	1·63	4	1·43	--	--	4	1·70
Retort carbon, new, as furnished	8·0	20	1·94	4	1·59	--	--	--	--	--	--	--	--
Retort carbon, new, boiled in HCl	8·0	22	1·81	3	1·52	--	--	--	--	--	--	--	--
Retort carbon, new, boiled in H_2SO_4	8·0	20	1·92	2	1·76	26	1·54	2	1·45	16	2·17	2	2·05

TABLE III.

Electromotive force of the polarizing battery	=1·00 D.	1·72 D.	3·44 D.	5·16 D.	6·88 D.
Density of current in the voltameter (mm, mg, sq. mm.)	= ----	0·00006	0·00037	0·00073	0·00112
For 5 per cent H_2SO_4 between platinum electrodes	P= ----	1·46 D.	1·95 D.	2·01 D.	2·07 D.
Density of current in the voltameter (mm, mg, sq. mm.)	=0·000002	0·00006	0·00019	0·00043	0·00067
For 6 per cent NaCl between carbon electrodes	P=0·99 D	1·34 D.	2·17 D.	2·37 D.	2·49 D.

ing from which P was calculated being given under "sec." in seconds. I would here remark, that owing to the difference of rapidity with which the polarization vanishes for different combinations, the quickest time at which it was possible to read off the position of the needle, after opening the primary current, varied from 1 to 5 seconds. In columns 13 and 14 are the values observed and calculated by Exner, and the last column contains the values newly calculated from the thermo-chemical equivalents of J. Thomsen,* which are given in convenient form in a table in the last edition of Richter's Anorganische Chemie. The calculations were made according to the scheme given in Table IV.

TABLE IV.

Daniell.	$ZnSO_4-CuSO_4$ $248{\cdot}4-198{\cdot}3=$	50·1	1·00 D.
H_2SO_4	$H_2SO_4+H_2O-H_2SO_4$ $210{\cdot}7+68{\cdot}3-210{\cdot}7=$	68·3	1·36 D.
HCl	HCl $39{\cdot}3=$	39·3	1·57 D.
NaCl	$NaCl+H_2O-NaOH$ $96{\cdot}5+68{\cdot}3-111{\cdot}8=$	53·0	2·12 D.
NaOH	$2NaOH+H_2O-2NaOH$ $223{\cdot}6+68{\cdot}3-223{\cdot}6=$	68·3	1·36 D.
$NaNO_3$‡	$2NaNO_3+3H_2O-2HNO_3-2NaOH$ $212+204{\cdot}9-98{\cdot}2-223{\cdot}6=$	95·5	1·91 D.
NaI	$NaI+H_2O-NaOH$ $70{\cdot}3+68{\cdot}3-111{\cdot}8=$	26·8	1·07 D.
$Cu(NO_3)_2$‡	$Cu(NO_3)_2+H_2O-2HNO_3$ $82{\cdot}2+68{\cdot}3-98{\cdot}2=$	52·3	1·04 D.
$CuSO_4$	$CuSO_4+H_2O-H_2SO_4$ $198{\cdot}3+68{\cdot}3-210{\cdot}7=$	55·9	1·12 D.
$ZnCl_2$	$ZnCl_2$ $112{\cdot}8=$	112·8	2·25 D.
$ZnSO_4$	$ZnSO_4+H_2O-H_2SO_4$ $248{\cdot}4+68{\cdot}4-270{\cdot}7=$	106·0	2·12 D.
$MnCl_2$‡	$MnCl_2$ $128{\cdot}0=$	128·0	2·55 D.
$MgSO_4$‡	$MgSO_4+3H_2O-H_2SO_4-\overset{(dry)}{Mg(OH)_2}$ $323{\cdot}0+204{\cdot}9-210{\cdot}7-217{\cdot}2$	100·0	2·00 D.
$AgNO_3$‡	$2AgNO_3+H_2O-2HNO_3$ $46{\cdot}6+68{\cdot}3-98{\cdot}2=$	8·4	0·34 D.
$Pb(NO_3)_2$	$Pb(NO_3)_2+H_2O-2HNO_3$ $97{\cdot}9+68{\cdot}3-98{\cdot}2=$	68·0	1·36 D.

Values marked with a (‡) in tables I and IV are uncertain because we do not know what secondary reactions take place, nor do we know, if and to what extent the secondary reactions† affect the polarization. Table II contains the polarization of 5 per cent H_2SO_4, 6 per cent HCl and 6 per cent NaCl, between the electrodes named in the first column; other-

* J. Thomsen, Kolbe's Journ., xi, p. 18 and xii, 1875.

† Compare here, Wiedemann Galvanismus, ii (2), p. 498, § 1130–1146, 1874, on the effect of primary and secondary reactions in voltameters.

wise the abbreviations are to be understood as in Table I. Table III gives the polarization as it increases with the increase of the force of the primary battery from E=1·00 D. to E=4 Bunsen=6·88 D. and will be understood without further explanation. In all cases the force of the Daniell battery was taken as the unit of electromotive force.

7. Conclusions.

Although, as is well-known, the force of polarization in general varies according to the chemical affinities of the elements or radicals separated, still we cannot, yet at least, calculate the electromotive force of polarization from the thermal equivalents of the reactions, because we do not know which of the reactions, primary or secondary, should be taken account of, nor do we know their thermal equivalents. Table I seems to establish what has just been said; in most cases the calculated value is much smaller than the observed one, and the latter is not a true maximum value, but only the largest attainable with two or three Bunsens respectively, in the polarizing circuit. Especially in the case of H_2SO_4 is the difference great, and in fact, if its polarization were only P=1·36 D., as calculated one ought to get a good evolution of gas with two Daniell cells, which, on the contrary were only able to evolve 5^{ccm} in 17 hours instead of the 300^{ccm} which they could have produced had the polarization been only P=1·36 D.

Tables I and II confirm the earlier experiments, showing that the polarization is not independent of the substance of the electrode, even when the latter remains chemically unaffected.

Exner* published a series of experiments to prove that the electromotive force of polarization keeps equal to that of the primary battery, when the latter is increased from zero upward, until it reaches the point where the evolution of gas becomes visible, and that from this point it (the polarization) remains constant, no matter how much we increase the force of the primary battery. This result is contradicted by those given in Tables I and III, inasmuch as with two Bunsens =3·4 D., the evolution of gas was very easily visible.† Exner's results are in so far in harmony with the theory of the conservation of energy as that no one will contend that a weaker electromotive force can overcome a stronger; but Helmholtz‡ has shown for

* F. Exner, Wied. Ann., v, p. 388, 1878.

† The results given in Tables I and III only confirm the previous ideas regarding the dependence of the polarization upon the density of the current upon the surface of the electrode.

‡ Helmholtz, Pogg. Ann., cl, p. 483, 1873; compare also F. A. Flemming, Phil. Mag. V, i, p. 142, 1876; A. Bartoli, Nuovo Cim. III, iv, p. 92, 1878, III, v, p. 203, 1879.

platinum, and from results here obtained it would seem to be true for at least carbon also, that an electromotive force which is theoretically too weak to decompose the solution between the platinum electrodes still does generate a current through a voltameter, which was originally free from all dissolved gases, and polarizes the electrodes, assisted by the occlusion of the evolved gases by the platinum.

It is difficult to explain according to the "chemical theory" why, on closing the primary circuit, the polarization does not immediately reach its maximum value instead of doing so gradually, as is the case. According to the "contact theory" the polarization of H_2SO_4 between platinum electrodes, on closing the primary current, increases gradually until we have a platinum kathode saturated with hydrogen opposed to the anode saturated with oxygen, just as in the polarization of $ZnSO_4$ it increases until we have the kathode covered with zinc, opposed to the Pt | O anode, in other words, until our voltameter has become a Smee cell.

That solutions of HCl and NaCl between the same electrodes give different values of the electromotive force of polarization, Exner considers as an argument against the contact theory, because we have the same gases acting upon the same electrodes. The reason, however, is evident. In the one case the series acting is

$$\text{Pt} \mid \text{H}+\text{H} \mid \text{HCl}+\text{HCl} \mid \text{Cl}+\text{Cl} \mid \text{Pt}. \tag{1}$$

and in the other case

$$\text{Pt} \mid \text{H}+\text{H} \mid \text{NaOH}+\text{NaOH} \mid \text{NaCl}+\text{NaCl} \mid \text{Cl}+\text{Cl} \mid \text{Pt}. \tag{2}$$

That these two series should not give the same electromotive force is what one would expect.* A test experiment, however, gave the following equation,

$$\text{Pt} \mid \text{NaOH}+\text{NaOH} \mid \text{NaCl}+\text{NaCl} \mid \text{Pt}=0{\cdot}39 \text{ D}.$$

and furthermore it gave no difference in the polarization when the kathode as well as the anode was surrounded with NaCl solution, and when the vessel containing the kathode was filled with NaOH solution, thus showing that series (2) really represents the forces acting in the polarization of NaCl solution between platinum electrodes.

The secondary reactions in some cases must be very peculiar; for example in the electrolysis of a solution of $MnCl_2$ there was no chlorine gas evolved, and the anode became covered with a brownish-red film insoluble in H_2O, H_2SO_4 or dilute HCl, but concentrated HCl dissolved it off to a reddish-brown solution which gave off quantities of free chlorine. The chlorine had

* Aryton and Perry, Trans. Roy. Soc., i, p. 34, 1880; Helmholtz, Wied. Ann., iii, p. 201, 1878; F. Moser, ibid., p. 216; and E. Kittler, Wied. Ann., xii, p. 577, 1881.

apparently simply added itself to the $MnCl_2$, thus forming a higher chloride of manganese.

Adolfo Bartoli* in an interesting research on polarization proceeds as follows. A very strong battery (400 zinc-carbon cells) is closed a very short time (0·004 sec.) through the voltameter, and the polarization calculated from the first elongation of the galvanometer needle, as a function of the amount of transmitted electricity. All the connections were made and broken automatically. He finds for the following combinations the following maximum values.

Platinum electrodes and

H_2O	HCl	HBr	HI
2·00 D.	1·30 D.	0·94 D.	0·58 D.

The values calculated from the thermal equivalents are

1·36 D.	1·57 D.	1·13 D.	0·52 D.

These values of Bartoli's agree with those given in Table I, but not at all with the calculated ones, so that we cannot calculate the polarization from the thermo-chemical equivalents, even under these circumstances.

Conclusion.

The result of this research may be summarized in the four following propositions. 1. The generally accepted explanation of the variations of the force of the Smee battery, which ascribes them to the variations of the hydrogen polarization of the platinum plate, must still be looked upon as correct. 2. The electromotive force of polarization is by no means independent of the substance of the electrodes. 3. We can not calculate the polarization from the thermo-chemical equivalents. 4. The electromotive force of polarization can be raised considerably above that necessary to produce a visible evolution of gas and the former results upon this question are confirmed.†

* Adolfo Bartoli, Il Nuovo Cim. III, vii, p. 234, 1880.

† Compare Wied. Galv.. i, p. 681, 1874.

ART. XXX.—*The Age of the Southern Appalachians;* by JNO. B. ELLIOTT, M.D., Professor Chemistry, University of the South, Sewanee, Tenn.

THE following paper is the result of several geological excursions made during the past five years in the mountain regions of Tennessee, Georgia and the Carolinas. They were directed along the lines mapped out by Tuomey, Safford, Bradley and Kerr; and were undertaken with the desire of obtaining by personal observation sufficient data for an opinion concerning the geological age of this debatable region.

The relative positions of the geological sections made during these excursions need explanation. If a line be drawn from Cleveland, Tennessee, southeastward to Atlanta, Georgia, and from Atlanta, Ga., northeastward to Spartanburg, S. C., a triangular area will be outlined within which lie the plateau-land of northeast Georgia and a portion of the same plateau region in Tennessee and N. Carolina. Beginning at the point where the Hiwassee River breaks through the Smoky Mountains east of Cleveland, Tenn., this range can be traced far southward into Georgia. Frog Mountain in Tennessee and the Cohuttas and Fort Mountain in Georgia are the last lofty peaks of the great chain. Towards the south the prolongation of Fort Mountain fades away into the Coosawattee Hills to rise again further south into the prominent peak of Sharp Mountain. Still southward of Sharp Mountain an imposing mass of lofty hills, between Cartersville and Allatoona, form the last conspicuous landmarks of the range.

Beginning again at Cæsar's Head, S. C., where the Blue Ridge enters the eastern extremity of our triangular area, this chain of mountains leads us southwestward into Georgia. In the first portion of its course the mountain range trends westward forming the boundary line between the Carolinas. It then enters northeastern Georgia, forming the boundary line between Rabun and Townes Counties, from which point it traverses Georgia in a southwesterly direction to Jasper, in Pickens County, Ga. Along this latter portion of its course it forms the center of the water-shed between the streams that flow northwestwardly into the Oostanaula River and those that flow southeastwardly into the Etowah. Beyond Jasper the chain fades away into the hills which represent the southern extension of the Smoky Mountains. The Smoky Mountains and the Blue Ridge thus run together in Georgia and offer short sections near and at their point of coalescence along which much can be learned that will throw light upon the relations of these ranges in their more widely separated portions.

The first of these sections was made in the summer of 1878. This section extended from Cleveland, Tennessee, up the Ocoee River to Ducktown; from Ducktown eastward to Murphy, N. C., and from Murphy westward down the Hiwassee River back to Cleveland.

The second section was made in the summer of 1879. It extended from Greenville, S. C., to Saluda Gap; from Saluda Gap to Cæsar's Head and Table Rock, and from Cæsar's Head to Hendersonville, N. C.

The third section was made in the summer of 1880 and extended from Cartersville, Georgia, to Acworth, Ga.

The fourth section was made during the past summer (1882), and extended from Dalton, Georgia, eastward across the Smoky Mountains to Elijay, Georgia; from Elijay still eastward across the Blue Ridge to Armacolola, Ga.; from the latter place westward again to Jasper and from Jasper to Dalton.

By glancing at a good map of this region it will be seen that the first section crosses the Smoky Mountains at the western extremity of the triangular area spoken of. The second section crosses the Blue Ridge at the eastern extremity; the third section crosses the southward extension of the two ranges after their coalescence; while the fourth section crosses at an intermediate point where the two mountain chains are about twenty-five miles apart. This latter was planned with the design of utilizing in as short and complete a section as could be obtained the lithological experience gained in the other three.

Section I. From Cleveland, Tenn., to Ducktown, Tenn., and Murphy, N. C.

This section was made to study the characteristic features of the Knox, Chilhowee and Ocoee formations as described by Professor Safford. It will be given very briefly as it has been

Lower Silurian..	Canadian	Chazy	Maclurea Limestone.
		Quebec	Knox Dolomite.
			Knox Shale.
		Calciferous	Knox Sandstone.
	Primordial	Potsdam	Chilhowee Sandstone.
		Acadian	Ocoee Conglomerate and Slates.
Archæan.......			

already made known through Professor Safford's report and Professor Bradley's article on this region. It is considered of

importance here because some conclusions drawn by Professor Bradley are regarded as founded in error, and the conclusions bear with force upon the question of the supposed age of the formations about Ducktown. The equivalents of the Tennessee formations are given for the convenience of the reader.

Nothing can be added to the description given by Professor Safford of the formations occurring in this section to Ducktown. From Cleveland to the mouth of the Ocoee gorge the regular succession of the beds of the Knox Group were crossed. But few outcrops of the sandstone could be identified. (A still more marked absence of the sandstone is noticed in the 4th section made south of this in Georgia.) After passing over the Knox and by the outcrop of the Chilhowee forming Starr's Mountain, the Ocoee conglomerate is met about a half mile beyond Parke's mill. The conglomerate is composed of pebbles of quartz and feldspar, varying in size from that of a small bullet to a pigeon's egg. The rock is massive. The slates vary from a dark blue-black and dense, to grayish and greenish and less dense forms. The conglomerate and slates are conformable. The dip is S.E. at high angles. The formation, where the dark slates occur nearest the western outlet of the gorge, gives rise to massive mountains. For the first five miles the conglomerate is much the most abundant. For the succeeding seven miles the slate largely predominates, containing here and there layers of conglomerate. In the twelve miles passed over, the conglomerate undergoes a gradual metamorphism, and when it reappears again at the end of this distance it has become a fine grained gneiss in which all distinction of pebble forms has disappeared. Within three miles of Ducktown shales set in, now become a hydromica schist. Up to Ducktown the strata have a S.E. dip at high angles, in some places vertical. After passing Ducktown over Wolf Mountain gap, the gneiss sets in again with N.W. dips showing that a synclinal had been passed near Ducktown. The gneiss here is lighter colored and less massive than the gneiss of the Smoky Mountains. As will be seen in the fourth section this synclinal near Ducktown appears to coincide with one crossed near Mountaintown, Georgia. Wolf Mountain (a low ridge) is made up of this gneiss with over and underlying semi-metamorphic shales. Beyond Wolf Mountain, to the east, Franklin Mountain was crossed composed of the same gneiss with N.W. dips. Still farther east, at Rice's, about six miles in an air line from Ducktown an anticlinal was passed and the dip changed to S.E. The beds forming this anticlinal were composed of alternating layers of hydromica schists and gneiss. Two miles east of Rice's the hydromica schists were found containing staurolite and garnets; dip still S.E. at high angles.

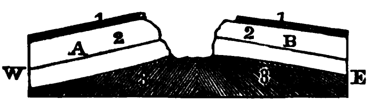
These dips do not change until the marble beds of the Knox dolomite, mentioned by Professor Bradley, are reached at Murphy, N. C. Professor Bradley's description of these beds were verified in every particular. Upon the return trip down the Hiwassee S.E. dips continued until Davidson's was reached near Grape-vine Creek. Here the anticlinal is crossed which was crossed on the other route at Rice's, east of Ducktown. It occurs, as Professor Bradley states, in hydromica schists and gneisses, just as it was found to occur at Rice's. From this point N.W. dips set in and continue to Hammonds (abreast of, but N.E. of Hennegars), where a synclinal is crossed bringing in the S.E. dips that continue beyond the State line.

This section has been run over thus briefly because of the full description already given. It was undertaken, as has been mentioned, to study the formations and to confirm Professor Bradley's section. It is inserted here because Professor Bradley refers the Ducktown mines to the anticlinal at Davidson's, whereas the Davidson anticlinal was found to pass six miles east of Ducktown to Rice's. Ducktown is in a synclinal that corresponds with the synclinal at Henegar's. This is an important point, for a later section in Georgia south of and parallel to this crosses a synclinal and then an anticlinal before reaching the marble beds of Elijay, and leads to the belief that the hydromica schists and the less massive and light colored gneisses, at and east of Ducktown, belong to the Knox group. This would place the hydromica schists and gneisses in the anticlinal at Davidson's and Rice's not below the Ocoee but above it in the Knox. In the four lines along which these formations have been crossed west of the Blue Ridge, a recurrence of the typical Ocoee conglomerate with its dense blue black slates, as shown along the line of the Great Smoky Mountains, has nowhere been seen.

Section II. From Greenville, S. C., to Cæsar's Head and Hendersonville, N. C.

The object of this section was to verify the section of Cæsar's Head and Table Rock, given by Professor Tuomey in his report upon the geology of South Carolina in 1848, p. 73.

The following is a copy of Professor Tuomey's section:



A. Table Rock. B. Caesar's Head. 1. Hornblende Slates. 2. Gneiss. 3. Hornblende Slates.

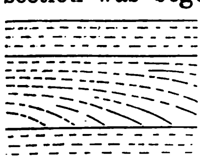
The importance of the unconformability reported by Professor Tuomey can at once be seen. If the great strata of gneiss, forming the Head and Table Rock, are unconforma-

ble to the underlying hornblende slates, there is afforded a starting point for the classification of the rocks of the Blue Ridge. The existence of such a line of division becomes a factor of fundamental importance in the determination of the age of these metamorphosed strata. Not only does Professor Tuomey assert unconformability, but he represents in his section the existence of an anticlinal axis of which Cæsar's Head and Table Rock are the eastern and western declivities. He furthermore teaches that the great gneiss bed was deposited over a preëxisting anticlinal in the underlying hornblende slates, and that a subsequent upheaval along the same anticlinal axis produced anew an anticlinal in the gneiss-bed.

The road from Greenville to Cæsar's Head passes over a not very hilly country. The formations passed over are in a state of almost complete decomposition, but here and there along the road the stratification could be plainly seen. The formations noticed were a black, hornblendic slate, decomposed to some distance beneath the surface, giving rise to red clay hills and very red colored roads, and here and there a lighter colored very friable siliceous gneiss, giving rise to light colored and sandy roads. From observations subsequently made (see sections 3d and 4th), these formations are regarded as the metamorphosed equivalents of the Knox sandstone and shale.

As the road ascends the Saluda range to the Head it gradually traverses the entire thickness of the great gneiss bed that forms the chain. The gneiss appeared in heavy massive beds, with dip N.E. 15°. Here and there layers of hornblende slates were noticed mingled with the gneiss. The slates, though more irregular and broken and varying locally in dip, did not at any point show general unconformability. The gneiss cap at Cæsar's Head was found to be of great thickness. At the point of the Head several hundred feet of it are exposed in a vertical precipice, the mass being composed of heavy layers of the gneiss lying one upon the other, with dip N.E. about 15°. The rock itself is a very dense quartzitic gneiss, and is almost identical with the typical quartzitic gneiss of the Ocoee as found at Gregory's. (Sec. 4th).

In order to test the question of existing uncomformability, a section was begun at the foot of the western exposure of the



precipice, and was run down a ravine to the Saluda river at the base of the mountain. A short distance down this ravine a partial exposure of hornblende slate was seen. In this exposure local flexure was noticed, (see fig.) but the beds of gneiss above and below the slate were conformable with one another, and had the dip of the cap rock above. The gneiss was more siliceous and

friable than the summit mass. The ravine was followed down through the "dismal" for a mile and a half to its junction with the Saluda river. The gneiss beds continued to show the same dip as the summit rock down the entire ravine. Here and there layers of hornblende slates alternated with the gneiss, but were always conformable. The section was continued up the Saluda river to the falls. The hornblende slate was also met with along this section, but it was always found conformable with the gneiss with which it was bedded.

The following day a trip was made on foot across from Cæsar's Head to Table Rock. The distance is ten miles. On this trip another section of Cæsar's Head was obtained, but no unconformability could be discovered, save such as could be easily accounted for by local disturbance. Table Rock was approached from the N.E., and the ascent was made up the wooded slopes to the base of the enormous mass that forms the Table. No good exposure of the strata could be obtained on the ascent, as it was made up a "ridge." When the base of the Table was reached the mass was seen to disappear beneath the soil without change of bedding or dip. The dip was the same as the mass at Cæsar's Head, N. E. about 15°, and the rock identical in nature, a quartzitic gneiss. The base of the rock was examined along its northern flank, as along this face the mass is exposed to a lower level than on any other side. Upon this northern flank there is a precipitous exposure of the Table for nearly a mile, with an almost vertical precipice of about 800 feet. The mass was composed, as at Cæsar's Head, of superimposed beds of the gneiss. About forty feet above the base of the precipice a layer of contorted hornblende slates is included among the beds of gneiss. This layer is about eight feet thick and so contorted as to be in some places completely reflexed upon itself. Nevertheless, it was perfectly evident that the contorted layer was of the same age and formation as the enclosing gneiss. If this layer had been seen with the immediately over- and underlying beds hidden from sight, uncomformability would have been suggested. This explained the local contortions in the slates noticed in ascending the Saluda range and in the section of Cæsar's Head. Near the middle point of the northern exposure of the Table Rock, where the rock is exposed to its lowest point, a precipitous ravine descends to the valley below. The bed of this ravine was made up of a series of precipitous ledges, down which a complete section of the mountain mass could be obtained. Down this ravine each successive ledge of rock was examined. The ledges were composed of the same gneiss encountered in the section at Cæsar's Head. Here and there layers of hornblende slates were likewise found, but they were conformable with

the enclosing beds of gneiss, while the gneiss had the same dip as the overlying mass composing the Table. The ravine gave a complete section to within two hundred and fifty feet of the valley level. The elevation of the summit above the valley is about 2,300 feet.

The conclusion was unavoidable that Table Rock was but an outlier of Cæsar's Head, composed of the same gneiss and hornblende slates, having the same N.E. dips with all of the beds conformable from summit to base. This revelation was a great disappointment, as the section had been made simply to verify the work of Professor Tuomey, with the hope that it would afford a key to the problem of the age of these mountains. From the absence of all Archæan characteristics, there was no warrant for referring the gneiss to any formation older than the Ocoee. This hypothesis, however, needed the subsequent sections made in Georgia to warrant its presentation here. (See sec. 4th, and conclusion).

The topographical peculiarity of the Blue Ridge is a matter to be noticed, as it aids somewhat in explaining conclusions drawn when the mountain range had been studied at other points. Wherever the Blue Ridge is ascended from the S.E. the ascent is long and the elevation attained is great. When, however, the eye is directed from the elevation to the northwest, the observer realizes that he has ascended the southeastern slope of a great plateau. The mountain masses to the northwest appear to rise from the level upon which the observer stands. This was noticed by Professor Tuomey at Saluda Gap. It is very noticeable at Cæsar's Head. It is still more marked where observed near Burnt Mountain Gap, Georgia. Wherever streams flow down this southeastern edge waterfalls of great height and beauty exhibit themselves. The falls at Plumley Mountain, near Saluda Gap, the falls near Cæsar's Head, and those at Armacolola, Georgia, are all caused by streams precipitating themselves over the great monoclinal of the Blue Ridge. This unity of form is a connecting link in the question of identity of age.

The road from Cæsar's Head to Hendersonville is approximately parallel with the trend of the Blue Ridge, although several miles to the west of it. As the trip was made in a regular stage containing other passengers, nothing more than a superficial examination of the formation passed over could be made. The important point noticed and observed at one or two places was the conformability of the gneiss and hornblende slates. Nine miles from Cæsar's Head a new formation was first observed. It was a dove-colored fine-grained hornblende gneiss containing large feldspar crystals. The feldspar had more the appearance of pebbles than of crystals. It could be easily mistaken for a partially metamorphosed quartz con-

glomerate unless the pebbles are broken and examined. This formation at eleven miles from Cæsar's Head had a low S.E. dip. Time did not permit the tracing of this formation towards the Blue Ridge, but from the dip of the gneiss bed at Cæsar's Head the most plausible conjecture seemed to be that the dove-colored gneiss was above the former and therefore younger. This conjecture is strongly supported by the facts revealed in Sec. 4.

SECTION III.—FROM CARTERSVILLE TO ACWORTH, GEORGIA.

This is a short section along the W. & Atlantic railroad. To understand the relations of the formations passed over, it must be explained that the Knox Group of Professor Safford sweeps southward from Tennessee into Georgia. As it enters Georgia the trend of the formation is almost due south. The formation retains in Georgia the characteristic topography that marks it in Tennessee. The dolomite gives low cherty ridges; the shale, wide valleys. As will be seen in section 4th, when the Knox Group was traversed from Dalton to the Smoky Mountains, the dolomite was readily recognized, while the characteristic limestone of the shale assumed a more shaly structure than usual. The rare appearance of the typical sandstone was accounted for by the supposition that the sandstone had likewise passed into a more shaly condition resulting in some ridges composed of shale sufficiently siliceous to render it enduring. All of the country between the W. & Atlantic railroad and the Smoky Mountains is composed of this group with one or two outcrops of Trenton limestone. From Dalton the W. & Atlantic railroad runs south approximately parallel with the strike of this formation. As the railroad turns southeast from Kingston it begins to traverse the group. Just beyond Cartersville the road enters upon metamorphic strata. The section was undertaken to examine these latter.

As before mentioned, the lofty hills lying between Cartersville and Acworth are the last conspicuous elevations arising along the southern extension of the Smoky Mountains. As the topography of the Lower Silurian formations in Georgia is almost as characteristic as their rock structure the supposition was that the Ocoee formation would be found where the railroad passed through these hills. The section was made on foot along the railroad.

A half mile south of Cartersville a low rounded hill is skirted by the railroad. Upon its sides and summit a coarse breccia was found corresponding in superficial appearance with a similar mass seen in the Knox Group near the western extremity of Starr's Mountain in Tennessee. The nature of the

pebbles entering into the composition of the breccia in Tennessee was not examined. In the masses found in this hill near Cartersville barite was a notable constituent. This hill was succeeded by a wide valley in shale. East of this valley and bordering the Etowah River a second ridge was passed through, showing in the railroad-cut a light colored decomposing siliceous gneiss dipping 45° E. This gneiss seemed the undoubted equivalent of the Knox sandstone. East of the river a wide valley in shale is crossed, deep red in color, arising from the decomposition of iron-bearing rocks. Succeeding this the road skirts the base of a lofty hill (500 feet), composed entirely of dense quartzite. This occurred in the horizon of the Chilhowee and was regarded as its equivalent. Beyond this, near Stegalls a long cut was passed in shale. Decomposing masses in this shale were of the same texture and nature as the masses observed in the hill near Cartersville. After passing Stegalls, and just before reaching the Bartow Iron Works a cut in heavy shale showed a layer of very dark colored slaty shale. South of the Iron Works a vertical strata of the same dark colored slaty shale filled with conformable quartz seams was found. Just south of this a very high hill showed the same shale more siliceous and metamorphosed into a very hard micaceous gneiss containing large quartz masses. In a cut, before reaching Allatoona, vertical walls were found, composed of quartzitic gneiss with slaty layers, the slate dark colored. Two cuts beyond Allatoona showed, the first, a schistose chloritic shale bed; the second very dark slaty shale containing quartz masses. From the sharp and rugged topography of the country, and the quantity of very dark slaty shale, the strata passed over since leaving Stegalls were supposed to be the equivalent of the Ocoee. The formations were all conformable with dips varying from vertical to S.E. at high angles.

In the second cut beyond the last a massive porphyritic gneissoid rock was found. Upon its weathered surfaces this rock presented a mottled appearance, and upon fracture showed a greenish hornblende matrix enclosing an almost equal amount of white feldspar. The feldspar was determined to be orthoclase. This rock was regarded as a metamorphic form of the Ocoee. (A rock with identical characteristics was found afterward near Talking Rock, Georgia, on the eastern flank of the Coosawattee Hills.) This rock was met with in three successive cuts.

Succeeding this formation the topography of the country changed. The sharp hills disappeared giving place to low rounded ridges composed of sandy soil, no true rock could be seen. This was succeeded at Acworth by a long cut through

a deeply decomposed hornblende slate, giving rise to deep red soil. These two latter formations were supposed to be the equivalents of the Knox sandstone and shale. They are just such forms as are seen along the Air Line railroad where that road passes near the limestone about Gainesville and Clarkesville, Ga. The limestone at these latter places was regarded by Bradley as the limestone of the Knox Group.

SECTION IV.—FROM DALTON, GEORGIA, THROUGH ELLIJAY TO ARMACOLOLA, GEORGIA, AND FROM ARMACOLOLA THROUGH JASPER TO DALTON.

Dalton is situated upon the Knox dolomite. Between Dalton and Spring Place the Knox Group forms nearly the entire surface of the country. For two miles out from Dalton the regular succession of dolomite ridges and shale valleys is well marked and easily recognized, but no sandstone appears. Succeeding this, the characteristic regularity of the Knox topography is lost. The shale largely predominates, in some places very siliceous. The hills that are crossed do not present the continuous ridge appearance but are low and irregular. Along the road the distinct succession of the different beds cannot be easily determined. At the crossing of the Connasauga River a blue limestone mass was found such as characterizes the Maclurea limestone as seen in Sequatchee Valley. I was informed by the owner of the land that heavy limestone ledges crossed the river above and below the road. Pebbles and cobbles of the Drift were found on the elevations from forty to fifty feet above the flood plain of the river. Beyond the Connasauga the regular succession of dolomite ridges and shale valleys recurred until Spring Place was reached.

Shortly after passing Spring Place the road enters the shale and turns northeast parallel with the strike of the formation. Much of this shale was very siliceous, giving rise to sandy road beds. Turning eastward and passing from this formation the road crosses the dolomite with its characteristic chert followed by the shale with its characteristic limestone. This limestone of the shale is so peculiar that it deserves notice. Wherever met it is a dove-colored rock filled with interlacing calcite veins. Even where, as in some of its outcrops between Jasper and Spring Place, it has assumed the shaly structure of the bed enveloping it, its smallest masses can still be identified by these calcite veins. This is a constant characteristic. It is important, for the peculiarity mentioned by Professor Tuomey as marking the limestone of the mica slate in South Carolina is stated in these words—"the (lime) rock at this place is blue and intersected with calcite veins."

At this point the road enters an embrasure in the Smoky Mountains. The Cohutta Mountains lie upon the north and Fort Mountain upon the south, about four miles apart. Between these the Knox Group sweeps in and extends three miles beyond the line of the main mountain chain. The last appearance of the limestone of the Knox shale was seen at Gregory's, at the eastern limit of this reëntering angle. At Gregory's, also, the Ocoee conglomerate was first seen. Immediately upon leaving Gregory's an ascent of the mountain chain was begun. Here the road winds over two subsidiary ridges, or offshoots from the mass of Fort Mountain. The rock was Ocoee conglomerate, a dense and massive quartzitic gneiss, with layers of dense blue-black slates. Dip about 50° E. After crossing the first ridge a descent was made into the valley of Holly Creek, and up this valley the road wound in a second ascent over a ridge composed of the same rock. After crossing the second ridge the country became much less mountainous and the rock much less massive. Dip still east and southeast. Two miles from the crossing of the last ridge night overtook the party, and three miles had to be traversed after dark before shelter could be reached at Mountain Town. The next morning it was found that a synclinal had been passed, as the dip of the gneiss was N.W. 50°. The gneiss was light colored, siliceous and friable, enclosing decomposing feldspar crystals. This synclinal is just in the southwestern extension of the Ducktown synclinal. The gneiss suggests the dove-colored gneiss found near Hendersonville, N. C.

The change in the color of the gneiss gives light colored and sandier roads, and the change of the structure and nature of the rock causes much less massive and precipitous hills. From Mountain Town for about three miles and a half no change was noticed in the dip. Semi-metamorphic shales compose the great mass of the formation, with only an occasional layer of the gneiss. Heavy beds of gneiss recurred again upon nearing Elijay, with a change in the dip to S.E. On account of the nature of the road the point at which the anticlinal had been crossed could not be identified. On the slopes of the descent to Elijay, (the town being in a wide valley,) a light, dove-colored gneiss was found, containing feldspar crystals identical with that observed on the road to Hendersonville. A fine specimen of kyanite was also picked up at this point. At Elijay I was informed of the marble bed south of the town on Tulona Creek, and was shown specimens which were identical with that seen at Murphy, N. C. Specimens of psilomelane and copper ore were also exhibited.

Northeast of Elijay a heavy mountain mass trends N.E. and S.W. The local name for this is "Blue Ridge," but it is en-

tirely separate from the true Blue Ridge which lies eighteen miles to the east of Elijay. As this so-called Blue Ridge extends S.E. toward Elijay, it diminishes in elevation and forms the eastern limit of the valley in which Elijay lies.

The trip from Elijay was continued eastward up Carticary River, and a section of this eastern ridge was obtained. The rock was a massive conglomerate, with S.E. dip at high angles. It was judged to be Ocoee. The road led up the eastern flank of this ridge for several miles, the same rock showing along the roadway. The road then turns eastward and crosses the Carticary River. Above the flood plain of this river, on either side, heavy beds of Drift pebbles and cobbles were noticed.

East of the Carticary the topography becomes much less rugged and rocky. Rounded hills are passed over, showing semi-metamorphic shales and hydromica schists, in which the dip could only be occasionally determined. The surface was strewn with quartz, arising from the denudation of the schists and the scattering of quartz fragments from the included veins. At Heath's a very heavy vein of rich gold quartz was crossed. Esquire Heath crushed and panned some specimens for investigation. This vein is in the southwestern extension of the gold quartz vein mentioned by Bradley as passing from the head waters of Hiwassee River southwestward, near Blairsville, Ga. The road over this section was on a comparatively level plateau, and the true Blue Ridge could be seen a few miles east of Heath's as rather a low and unimposing line of lofty hills. The road from Heath's to the Blue Ridge continued in the same metamorphic shales with some schists; but little gneiss was seen. The succession of the dips could not be accurately followed from the nature of the formation. The Blue Ridge was not crossed by an ascent, but by a descent. The road led through a low gap in the ridge, and commenced a steep down grade. This descent continued for several miles by road. The rock was a massive heavy bedded gneiss, having such characteristics as elsewhere distinguished the Ocoee formation. This descent is over a monoclinal, dipping N.E. This great formation passes under the strata crossed over between Heath's and the point of descent. The Armacolola Falls is formed by the pitch of a stream over this precipitous monoclinal, and at the falls a fine section of the formation is obtained. Dip N.E. about 35°.

From Armacolola the road was taken southwestward to Jasper. The road ran approximately parallel to the monoclinal, constantly ascending to Burnt Mountain Gap. Burnt Mountain is a spur from the Blue Ridge, and in crossing it to reach Jasper, the level of the plateau is attained. From points along this ascent a clear idea could be obtained of the topography of

the surrounding country. The plateau traveled over from Elijay extended away to the northwest. Its level was approximately the same as Burnt Mountain Gap. Rising from it in the distance could be seen the mass of mountains near Elijay. To the southeast the hill country of eastern Georgia lay at least fifteen hundred feet below the level of the plateau.

Between Burnt Mountain Gap and Jasper the road descends. Sharp ridges were passed over, showing their bedded gneiss. The gneiss was neither so dark nor massive as the gneiss of the Blue Ridge monoclinal. The dips were irregular, varying as might be expected in a region of such disturbance. A mile before Jasper was reached the nature of the road changed, becoming level and smooth, suggesting a change in the formation.

Tate's marble quarry, two miles southeast of Jasper, was visited and examined. This locality is the one mentioned by Professor Bradley, and is exceedingly interesting on account of the light it throws upon the true age of some of the gneiss met in the preceding sections. The marble is exposed on the eastern side of a very deep and narrow valley. The exposure of the marble is about thirty feet thick, at the base of a precipitous ridge. The ridge is composed of mica schist and gneiss. The gneiss and the marble dip 40° E. On the west of the valley a sharp ridge rises, the summit of which is probably one hundred feet above the valley level. The top of this western ridge is approximately on the same plane as Jasper, so that the valley represents rather a deep trench in the formation. The western ridge is composed of thinly bedded gneiss, dipping S.E. under the marble. Some layers were light colored and filled with feldspar crystals, such as characterize the layer found west of Elijay and near Hendersonville, N. C.

If the gneiss of this ridge is metamorphosed Knox sandstone, which seems the only possible conclusion, it gives a clue to the age of the formations with which it occurs elsewhere. Here it immediately underlies the marble which shows some tremolite, as does the marble at Murphy. The marble bed in the Elijay Valley is also east of the beds of the same gneiss found upon the western slopes descending toward Elijay. From the relations of the gneiss at the Jasper marble quarry it would seem proper to refer the gneisses and semi-metamorphosed shales between Mountain Town and Elijay to the Knox. The same assignment would be necessary for the formations between Heath's and the Blue Ridge monoclinal.

The trip from Jasper to Spring Place was somewhat of a reversal of the section north of it through Elijay. The only difference being that Jasper is at the southwestern extremity of the Blue Ridge, or at least of that massive monoclinal which

gives the lofty mountains. Jasper is twenty-two hundred feet above the sea, but the mountains fade out northeast of it. Southwest of Jasper the "divide" is continued towards the southern extension of the Smoky Mountains, but no mountains proper are seen. The country northwest of Jasper over which the road to Spring Place leads is rolling but not rocky. The roadway is smooth and light colored, just such as is given by the Knox Group in Georgia and Tennessee. Two miles out from Jasper towards Talking Rock two ridges were crossed showing much quartzite strewed over the surface. Beyond this shale occurs with northwest dips, followed by an exposure of thin bedded gneiss with the same dip. The road continued on over shales with a recurrence, five miles from Jasper, of gneiss dipping N. 30°. At this latter point was found some dove-colored gneiss with feldspar crystals. The country beyond this was comparatively open and level in shale. This was succeeded by a ridge showing gneiss with N.W. dips, followed by a synclinal in the shale. The shale with S.E. dips continued through a wide valley bounded by a ridge covered with quartzite pebbles and showing beds of mica schists.

Ten miles from Jasper at Talking Rock Creek a bed of porphyritic gneiss was found similar to that found in Section III on the W. & Atlantic railroad. The bed on the W. & Atlantic railroad was found just between the metamorphic beds on the west, supposed to be Ocoee, and the gneissoid beds and decomposing hornblende slates on the east, near Acworth, supposed to be Knox. The relative position at Talking Rock was the same, namely, the shales and light colored gneisses lying east toward Jasper, being Knox, while toward the west was encountered undoubted Ocoee. Over this country to the west the road crossed and wound in among the heavy ridges of the Coosawattee hills composed of Ocoee gneiss and shale. The typical dense and massive Ocoee gneiss with its accompanying black slate was encountered only upon the western slopes of this belt where the formation borders upon the Knox Group. From the Coosawattee River (which was crossed just at the junction of the Ocoee with the Knox), to Spring Place the regular succession of the Knox Group was encountered. Fine exposures of the limestone of the shale show just after crossing the river near Nolan's. Beyond this to Spring Place the shale predominates. The limestone of the shale passes into a shaly condition, still retaining, however, the calcite veins in its smallest masses. No typical Knox sandstone was seen, but some prominent ridges were crossed composed of very siliceous shale and were regarded as the possible representatives of the Knox sandstone.

Conclusions.

The characteristics from which conclusions can be drawn concerning the age of the formations crossed in the several sections, are:

Relative position, lithological peculiarities and topography.

In these conclusions the fourth section will be considered first. The formation that permits no question as to its geological place is the marble bed at Jasper. No one who examines the Jasper marble and the marble at Murphy can hesitate as to the identity of the two. Professor Bradley, who examined the marble at Elijay, regarded that also as the same. Taking this as a fixed horizon from which age can be reckoned we find at Jasper a gneiss underlying the marble and so situated as to leave but little doubt that it is the equivalent of the Knox sandstone. This gneiss has certain characteristics that render it easy of recognition elsewhere, even when the marble does not accompany it. It is a light colored friable rock containing feldspar crystals; some of the layers are dove-colored, while others are drab. The dove-colored layer is so marked as to be instantly recognized wherever seen. These varieties of the gneiss are found together in the ridge west of the marble bed at Jasper. They differ from the Ocoee gneiss in being softer, and even "sandy," while the Ocoee is quartzitic and dense; in being thin bedded, while the Ocoee is generally thick bedded and massive; in being light colored, while the Ocoee gneiss is dark. Wherever these lighter colored gneisses are found the topography is hilly rather than mountainous, and these lighter colored gneisses are always accompanied with semi-metamorphic shales (also light colored where metamorphism is *partial*) which constitute by far the greater mass of the formation into which the two classes of rocks enter. These peculiarities when once recognized enable the observer to identify these formations wherever seen.

The light colored gneiss was found in the N.W. dips of Wolf Mountain east of the Ducktown synclinal. They were found in the N.W. dips of the synclinal passed near Mountain Town. The dove-colored gneiss was found dipping S.E. under the marble at Jasper, and was found near Elijay where it must have been below the marble on Tulona Creek. It was also found between Jasper and Talking Rock in strata that were, from other considerations, deemed to be Knox. This same dove-colored gneiss was found near Hendersonville where it was judged to be above the supposed Ocoee of Cæsar's Head and Table Rock. In all of these positions the gneiss formations are associated with semi-metamorphic shales, or where metamorphism is more complete, with hydromica schists.

It should be stated that these lighter colored gneisses were at first regarded as varied forms of the Ocoee, but a final review of the sections, in the light of the Jasper beds, warrants, it is believed, the conclusions that follow. These conclusions briefly stated, are:

1st. That the plateau land of northeast Georgia is based upon a great synclinal in the Ocoee.

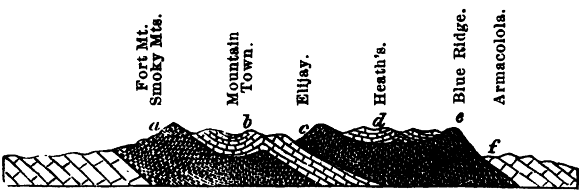
2d. That the Great Smoky Mountains may be regarded as the western monoclinal edge of this synclinal and the Blue Ridge as the eastern.

3d. That the great mass of the strata lying between these mountain chains in Georgia are above and younger than the Ocoee, and are composed chiefly of the metamorphosed equivalents of the Knox Group.

4th. That the formations east of the Blue Ridge are the metamorphosed equivalents of the Knox Group.

5. That the porphyritic gneiss of the W. & Atlantic railroad section is identical with the porphyritic gneiss found near Talking Rock and is a form of the Ocoee.

The second conclusion given above needs some qualification. In the Ocoee Gorge in Tennessee there are several faults in the Ocoee which would cause a repetition of monoclinal edges before the formation disappears as a final synclinal. This same characteristic marks the section of the Ocoee between Gregory's and Mountain Town, and between Talking Rock and the Coosawattee River. If the ridge east of Elijay is true Ocoee this general idea would require further modification as shown in the accompanying figure.



The blocked areas, Knox group; dotted, Ocoee.

The fourth conclusion is based upon the facts:

1st. That Professor Bradley regarded the limestone near Gainsville and Clarkesville, Ga., as of the same age as the Jasper marble.

2d. That the limerock spoken of by Professor Tuomey as occurring in South Carolina was by him regarded as identical with the limestone of northeast Georgia.

3d. That Professor Tuomey speaks of the limerock in Spartanburg and Laurens as of two kinds; the "limerock of the gneiss" and the "limerock of the mica slate." The former he

states contains actinolite (corresponding with the tremolite-bearing marble of Murphy, Knox dolomite), and the latter as being filled with interlacing calcite veins (corresponding with the limestone of the Knox shale wherever found).

Further, the Knox Group is easily followed from Tennessee to Cartersville, Georgia. These Knox beds are separated by but a few miles of Ocoee from metamorphic beds composed of just such forms as could be expected from the Knox Group. These latter beds are, moreover, east of the trend of the Ocoee of the Smoky Mountains as are the representatives of the Knox Group between Jasper and Talking Rock. Moreover, the Air Line railroad from Atlanta to Spartanburg, S. C., runs parallel with the strike of the strata east of the Blue Ridge and the same beds noticed near Acworth, i. e., sandy light colored gneiss, with mica schists and hornblende slates, show in every cut of the road. In these latter beds also occur the limerock of northeast Georgia and South Carolina.

These conclusions would require that the monoclinal of the Blue Ridge was formed by a downward faulting of the strata to the east of chain, and that along this line there has been sufficient displacement to separate the Knox strata of the plateau by two thousand feet from the same formation along the eastern flank of the chain. It is recognized that the conclusions here offered may seem more sweeping than the sections warrant; and it is also recognized that the work done has been after the manner of geological reconnaissances rather than of detailed surveys. When, however, it is remembered that in the four sections given the different formations have been crossed and recrossed six times; that these formations are marked by peculiarities of structure that are strikingly characteristic, and that they present a topography singularly uniform over immense areas, the conclusions will perhaps be deemed less inexcusable.

The writer takes pleasure in acknowledging his indebtedness to Professor Safford, whose report upon the Geology of Tennessee has been his guide in the study of these Lower Silurian formations; to Professor Bradley, whose section through these metamorphic areas he has carefully studied; and to Mr. Arthur M. Huger, of Charleston, S. C., to whom he is indebted for valuable information and suggestions, and for many collections of typical specimens from the formations traversed.

ART. XXXI.—*The Evolution of the American Trotting-Horse;* by WM. H. BREWER.

THE American trotting-horse is an example of a new breed of animals in process of formation. As yet it can hardly be called a definite breed in which the special and distinctive character is either fully developed in quality or satisfactorily fixed by heredity. Great progress has, however, been made, many individual animals have attained great speed, and all the better ones have derived their trotting excellence in part, at least, through heredity.

The origin of most breeds is involved in considerable obscurity, as to how much they are due to conscious and how much to unconscious selection, what motives led to this selection, how far the enhancement of the special qualities have been due to physical environment and how far to education, training, nourishment or cultivation. The formation of this new breed is so recent, the development of a special quality has been so marked, there is such an abundant literature pertaining to its history, the system of sporting "records" is so carefully planned and comprehensively conducted, and withal has become so extensive that we have the data for a reasonably accurate determination of the influences at work which led to this new breed being made, the materials of which it is made, and the rate of progress of the special evolution.

It is as an implement of gambling and sport that the trotter has his chief value to the biological student. Sporting events are published or recorded as the mere every-day use of animals is not, and the records of races give numerical data by which to measure the rate of progress. Similar data do not exist for the study of the evolution of any other breed.

Incidental to the preparation of a paper pertaining to this matter for farmers and breeders, I have compiled and collated certain data which have a scientific as well as economic value, the more interesting portion of which I condense for this paper.

The horse has several gaits which he uses naturally, that is, instinctively. And besides those which are natural he has been taught several artificial ones, some of which have been much used, particularly in the middle ages. But to trot fast was not natural to horses; when urged to speed they never assumed it, and until within a century the gait was neither cultivated nor wanted by any class of horsemen. A breed of fast trotters, had it been miraculously created, would doubtless soon have perished in that it would have had no use, satisfied no fancy and found no place in either the social or industrial world as it then was.

Before the present century the chief and almost sole uses of the horse were as an implement of war, an instrument of sport and ceremony, an index of rank and wealth and an article of luxury.

For all these uses, as then pursued, a fast trotter was not suited, nor was he better adapted to the heavy coaches over rough roads, or the slow wagon trains of armies. The horse best adapted to all these, however much he may have varied as to size, strength and fleetness, was one whose fast gait was the gallop or run rather than the trot. For leisurely horseback traveling the ambling gait (or *pacing* gait as it came to be called in this country), was preferred. With increasing use of horses for draft, certain heavy but slow breeds were developed in the Old World, of which the Dutch, Clydesdale and Norman breeds are examples.

The causes which led to the cultivation of the trotting gait in this country, and the evolution of a breed with which it should be instinctively the fast gait were various, and the separate value of each as a factor in the problem would be very differently estimated by different persons studying the subject from different points of view. Now that he is so valuable and plays such a part as a horse of use, it is easy to see why a breed of trotting roadsters should be produced to meet certain important demands of our modern civilization. But this does not explain how the process actually begun.

Reasoning *a priori*, the trotter, as a horse of use, should have originated in western Europe; as a matter of fact, he not only did not begin there, but he was unpopular there until well developed here. Locomotives began to draw armies to the battle-field, the war-horse declined in actual as well as relative importance, the modern, light, steel-spring, one-horse, convenient, business wagon as well as the modern buggy came into common use after trotting as a sport was established and after the gait had been extensively cultivated and bred to. The trotting-horse is specially adapted to various modern uses, but these uses followed his development, rather than led it, although in later days this factor has been an important one on the rate of progress.

The influences which originally led to the starting of the breed were more social than economical; a similar fact a century earlier marked the founding of that famous running breed, the English Thoroughbred. The origin of the trotter, however, was not so simple as that and several diverse social factors were involved, only the chief of which will here be noticed.

From early colonial times horses have been more generally owned by the masses of the people here than in any country of western Europe. They have had a more general use in agri-

culture and in business, their ownership or possession has had less social significance, and they have had less importance as instruments of gambling. The colonists who settled north of Delaware Bay, although of various nationalities, were largely those whose religious prejudices and social education was opposed to horse-racing. With the great majority of them it was considered a sort of aristocratic sport and at best led to unthrifty ways, even if not open to the objection of positive immorality. Consequently but few race-horses were imported into this region in colonial times. The original horse stock of the northern colonies came from several European sources. England, Holland, France and Spain certainly, and Sweden, Denmark, Germany, Ireland and Italy probably contributed to it. The blood from this variety of sources, variously mingled, formed the mongrel stock of the country. This was further modified by local conditions and local breeding assuming different characters in different places, and the hardships of horse life incident to a new country, with strange forage and a rough climate, caused deterioration in size and form. Early writers are unanimous on this point, but many add that what was lost in size and beauty was gained in hardiness and other useful qualities.

After the war of independence there was an improvement in the live stock of the country. English Thoroughbred horses were imported both for sporting and to improve the horse stock of the country, and horse-racing rapidly grew in favor as wealth and leisure increased. The export trade in horses to the West Indies increased, particularly from New England. Pacers were most sought for this trade, but sometimes trotters were advertised for.

As horse-racing increased in the last years of the last century the opposition to it revived, and in the earlier years of the present century this became ascendant, and stringent laws forbidding the sport were passed in most of the northern States. The prohibition was sweeping and the penalties severe.

Horse-racing was then a contest between running-horses, and during this repression of racing, trotting as a sport began, at first in a very unostentatious, irregular and innocent sort of way. Probably no people or class of people have ever bred good horses which they prized and were proud of, who did not find pleasure in seeing them compete in speed or show their fleetness in some way, and during the repression of racing (which meant running), trotting came in as a substitute, poor though it was at first. It had a sort of encouragement from very many thrifty people who were not sportsmen, and was in a measure considered a sort of democratic sport in which even plow-horses could take part. Racing of any kind in those

days was a strife between two or more things, as it still is in most countries; no one thought that a single horse could run a race alone, but the instinctive inclination to see a spirited horse in action could be mildly gratified by letting him trot, even if single and alone, and testing by the watch how quickly a given distance could be covered. So "timing" animals came to be practised. We hear of it on the Harlem race-course in 1806, four years after the laws forbidding horse-racing had been enacted, and again, a little later, near Boston, and it was reputed that certain horses could trot a mile in three minutes. This speed seemed so extraordinary that in 1818 a bet of a thousand dollars was staked (and lost) that no horse could be found that could trot a mile in three minutes. Some authorities date the beginning of trotting as a sport with this event. It is said that in betting the odds against the successful performance of the feat were great, which shows, strikingly, the enormous progress since made in developing speed at this gait.

In 1821, certain persons on Long Island were allowed by special statute to train, trot, etc., horses on a certain track, under certain restrictions, exempt from the penalties against horse-racing. Other organizations followed, and by 1830 the "training" of trotters was going on at several points, and trotting may be said to have become established as a sport. During this decade the record had been successively lowered to 2.40, 2.34 and 2.32. The times of performance were carefully taken at these "trials of speed," as the statute called them, and "records" became established by more formal sporting codes.

The ostensible object of these associations was the "improvement of the breed of roadsters;" driving single horses to wagons became fashionable and this led to the improvement of light one-horse wagons for business and pleasure. Those with steel springs were rare luxuries in 1830; by 1843, when the record of mile heats dropped to below 2.30, they were already common. During this thirteen years, the record had been lowered only half a second on mile heats, but three-minute horses were no longer rare.

The fashion of wealthy men driving a single fast trotter for pleasure was for a long time a peculiarly American one, and played an important part in the development of this breed. But, as stated earlier, many influences have contributed; changes in the modes of travel, changes in the methods of war, sentiments regarding horse-racing, the incentives of the course, the general improvement of roads, improvement in carriages, the needs of modern business requiring quick roadsters, these and other influences have all been at work.*

* For more details regarding the history of this development and the factors involved, see the paper already cited, Rep. Conn. Bd. Agr. for 1882, p. 215.

The material out of which this new breed is made is a liberal infusion of English Thoroughbred blood (usually more than two generations removed), with the mongrel country stock, previously described. There is a voluminous literature relating to special pedigrees and much speculation as to the comparative merits of the several ingredients of this composite blood.

Regarding the ideal trotter there is as yet a difference of opinion as to what the form should be, and it is too early to decide from actual results. That the gait is now hereditary, that it is the instinctive fast gait with some animals is certain, but whether this is due to inherited habit, inherited training, or to mere adventitious variation and selection, I will not discuss.

The gain in speed is given in the following table, which is the best records at mile heats, omitting the names of the special performers:

Date.	Best Record.	Date.	Best Record.
1818,	3.	1865,	2.18¼
1824,	2.40	1866,	2.18
"	2.34	1867,	2.17¼
1830,	2.32	1871,	2.17
1834,	2.31½	1872,	2.16¾
1843,	2.28	1874,	2.14
1844,	2.26½	1878,	2.13¼
1852,	2.26	1879,	2.12¾
1853,	2.25½	1880,	2.10¾
1856,	2.24½	1881,	2.10¼
1859,	2.19¾		

A sporting paper published in 1873 a list of three hundred and twenty-three horses, with their best records, down to the close of the preceding year. This first list of the kind known to me was very imperfect in its details; it was revised for the next year, and since that time many lists, in one form or another, have been published. The figures for the animals with records of 2.25, or better, are reasonably accurate; for the others there is much discrepancy. In the following table the numbers are my own, counting down to 1872, inclusive; the numbers after that date are derived from various lists published since that time in the sporting and breeding periodicals. From the very nature of the case, the table cannot be accurate in the larger numbers, but the numbers do not lose their value for comparison with each other from such faults as to the details of the larger numbers, and as such, it is undoubtedly the most significant series of numbers ever compiled to show progress in evolution, whether of a breed or species. The number of horses with records of 2.40, or better, is now stated to be over five thousand.

I leave it to mathematicians to plot the curves which immediately suggest themselves, and determine how fast horses will ultimately trot and when this maximum will be reached.

TABLE SHOWING THE NUMBERS OF HORSES UNDER THE RESPECTIVE RECORDS.

	2:30 or better.	2:27 or better.	2:25 or better.	2:23 or better.	2:21 or better.	2:19 or better.	2:17 or better.	2:15 or better.	2:13 or better.	2:11 or better.
1843	1									
1844	2	1								
1849	7	2								
1852	10	3								
1853	14	5								
1854	16	6								
1855	19	6								
1856	24	7	1							
1857	26	7	2							
1858	30	7	2							
1859	32	9	2	1	1					
1860	40	11	4	2	1					
1861	48	14	4	2	1					
1862	54	17	7	4	1					
1863	59	19	9	4	1					
1864	66	22	12	4	1					
1865	84	29	15	5	2	1				
1866	101	32	17	6	3	1				
1867	124	42	21	9	5	2				
1868	146	52	28	13	6	2				
1869	171	63	34	15	10	4				
1870	194	72	35	16	11	5				
1871	233	99	40	17	12	6	1			
1872	323	--	--	--	--	--	--			
1873	376	--	74	28	15	5	2			
1874	506	--	98	40	16	11	5	1		
1875	--	--	134	61	30	13	5	2		
1876	794	--	165	81	39	16	6	2		
1877	836	--	214	105	51	19	8	2		
1878	1,025	--	270	129	68	24	9	4		
1879	1,142	--	325	164	88	33	11	5	1	
1880	1,210	--	366	192	106	41	14	6	2	1
1881	1,532	--	419	227	126	49	15	7	2	1
1882	1,684	--	495	275	156	60	18	8	2	1

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Reciprocal Displacement of the Halogens.*—The ready displacement of bromine by chlorine is a well-known fact. It takes place with a notable evolution of heat, 4·6 calories being set free for each equivalent of the halogen brought into action when KBr is used, 6·8 calories when $BaBr_2$ is employed, but only 1·5 calories when AgBr is acted on. In consequence of the publication by Potilitzine, of some experiments tending to show the simultaneous production of the inverse reaction, Berthelot has been led to repeat the experiment, in order to examine more closely the thermo-chemical conditions. In this investigation he has discovered real intermediate compounds, hitherto unsuspected, such as metallic perbromides, bromine chloride and metallic chloro-bromides, formed in these inverse reactions, the heat of formation and of dissociation of which explain the phenomena observed. Thus his experiments showed that KCl, acted on by one equivalent of pure bromine, produced no appreciable effect either cold or hot. With three equivalents of bromide the same result took place; but with nineteen equivalents, an hour and a quarter of heating to redness and four distillations backward and forward, 5·5 per cent of the chloride was decomposed. After four hours and nine distillations, 7·8 per cent was displaced. With $BaCl_2$, treated with twenty-one equivalents of bromine, after four hours of heating to redness and eight distillations, 23·2 per cent was decomposed. With AgCl, with two equivalents of Br in the cold five days, 4 per cent was decomposed. With seven equivalents, in the cold five days, 7·2 per cent. With twenty-one equivalents, at a red heat for three hours, six distillations, 97 per cent. Now bromine chloride is a product common to all these reactions; and gaseous bromine uniting with gaseous chlorine produces liquid BrCl evolving 4·6 calories. Hence, this heat of formation suffices to explain the partial decomposition of silver chloride by bromine in the cold: $AgCl+Br_2$ (gas) $=AgBr+BrCl$; $-1·5+4·6=3·1$ calories. So with the perbromides: $KBr+Br_2$ (gas) $=KBr_3$ evolves 10·9 calories if the product is solid, 11·5 if dissolved. $BaBr_2+Br_4$ (gas) $=BaBr_6$ evolves 20·8 calories when dissolved. The heat of formation of these bodies accounts for the inverse reactions of potassium and barium chlorides: $KCl+Br_4=KBr_3+BrCl$: $-4·6+4·6+10·9=+10·9$ calories. And $BaBr_2+Br_8=BaBr_6+(BrCl)_2$: $-13·6+9·2+20·8=+16·4$ calories. Again, the chlorobromide of barium evolves heat as follows: $BaCl_2+BaBr_2=Ba_2Cl_2Br_2$, $+3·0$ calories. It therefore assists in the same direction. In certain chemical reactions the action is at first prompt, but becomes more and more slow as it goes on. The author attributes this to the formation of certain double salts and secondary compounds, the heat of combination of which exceeds the heat called into play in the direct decomposition of the simple

salts. These secondary compounds resist the first action and they would resist indefinitely if they were not dissociable by the heat. Their slow dissociation, however, is determined by the destruction of the simple salts which maintained the equilibrium, the same simple salts normally yielded by the reaction being reproduced. —*Bull. Soc. Ch.*, II, xxxix, 58, Jan., 1883. G. F. B.

2. *On the Action of Nascent Hydrogen in increasing the Activity of Oxygen.*—Some time ago HOPPE-SEYLER published some experiments showing that hydrogen in the nascent state, in presence of oxygen, induced energetic oxidation. Traube having called in question both the experiments and their explanation, the author has repeated them. He finds (1) that palladium-hydrogen in contact with oxygen colors potassium iodide and starch solution blue; (2) that these same bodies by their mutual action oxidize indigo-carmine solution to a yellow color; (3) that they oxidize oxyhæmoglobin solution to methæmoglobin; and (4) that they oxidize ammonia to nitrous acid. When recently ignited palladium is used instead of palladium-hydrogen, no such oxidation takes place, even in presence of hydrogen peroxide—contrary to the assertion of Traube. Recently ignited platinum or palladium foil placed in a mixture of indigo-carmine solution with hydrogen peroxide, causes no change, the liquid retaining its blue color for many days; while the same mixture pales and becomes yellow if the palladium foil is previously charged with hydrogen. The presence of the hydrogen peroxide has no influence upon the progress of the oxidation. Oxyhæmoglobin decomposes hydrogen peroxide into water and inactive oxygen without change of its color; while active oxygen or ozone converts it into methæmoglobin. Whether hydrogen peroxide is reduced by hydrogen in the nascent state cannot be determined by means of palladium-hydrogen, since it is decomposed by palladium itself into water and oxygen. But if to hydrogen peroxide, ferrous salts or other salts which are oxidized by ordinary oxygen be added, active oxidation takes place of indigo-carmine solution and the like, corresponding with the hypothesis of increased oxidation-activity by reduction. In the same way, benzene agitated with ignited palladium and air gives no result, while phenol is formed if the palladium contains hydrogen; and in greater quantity the more highly is it charged with the gas. So petroleum ether, when agitated with sodium hydrate and air, gives scarcely traces of oxidized products, even after a long time; while in presence of slowly oxidizing sodium in addition, sufficient quantities of the products were obtained to allow of the separation of the alcohols and acids, determination of fusing points, oxidation of the alcohol by chromic acid and elementary analysis. The author calls attention to the similarity of the action of rhodium-black upon formic acid, observed by Deville and Debray, with the action of a ferment upon this acid. And as he shows that the former action is due to rhodium-hydrogen, which acts like palladium-hydrogen above, he suggests a similar action for ferments, thus throwing

some light upon a subject of great physiological importance.—*Ber. Berl. Chem. Ges.*, xvi, 117, Feb., 1883. G. F. B.

3. *On the Phosphorescent Flame of Sulphur.*—HEUMANN, having raised the question whether phosphorus among the metalloids was the only one which underwent slow combustion at a low temperature, becoming luminous, has answered it satisfactorily by experiment. He finds that sulphur shows this phenomenon very well, though of course at a temperature higher than is required for phosphorus. If a heated rod of glass be dipped in pulverized sulphur, it becomes covered with the fused material which takes fire. If now the blue flame be blown out, the sulphur still continues to burn but with a whitish flame visible distinctly only in the dark. This white phosphorescent light is seen much better when the sulphur is heated rapidly to 180° on a plate in the interior of a metallic air-bath. White flames ten to twenty centimeters long flicker through the entire box. By regulating the gas this slow combustion may be continued for an hour without the appearance of the blue flame. Various kinds of sulphur were tried with the same result. Moreover many compounds of sulphur act in the same way: cinnabar, antimonious sulphide, arsenous sulphide, aurum musivum, sodium thiosulphate, potassium xanthate, sulphurea, all showing the white flame. The odor emitted when the sulphur thus burns is peculiar, recalling that of hydrogen persulphide, camphor and ozone at once and is the odor ordinarily ascribed to sulphur vapor. On examining it closely, however, nothing could be recognized in it but sulphurous oxide.—*Ber. Berl. Chem. Ges.*, xvi, 139, Feb. 1883. G. F. B.

4. *On the Hydrates of the Sulphydrates.*—An extended memoir has appeared, by DE FORCRAND, upon a class of crystallized bodies formed when hydrogen sulphide, at a low temperature, is passed into certain organic liquids in presence of water. These compounds he calls sulphydrated hydrates. The compound with hydrogen sulphide itself was observed by Wöhler in 1840. It is formed when H_2S and water are enclosed in a strong tube, in proportion as the former is decomposed and the H_2S liquefied. Brilliant crystals appear under a pressure of 17 atmospheres at the ordinary temperature. On heating to 30° they disappear but re-form on cooling. The author made his experiments in the tube of a Cailletet apparatus where the pressures and temperatures could be measured. At 29° the crystals decompose even under a pressure of 23 atmospheres. At 30° they are destroyed at 50 atmospheres. At low temperatures, however, the tension of dissociation is very feeble. On analysis the crystals contained from 12·4 to 16·6 molecules of water for one of H_2S. As the water was in excess in the latter, the author prefers the formula $H_2S(H_2O)_{12}$. In the first chapter of the memoir, the formation, crystalline form and composition of the sulphydrated hydrates of the simple ethers of the fatty series and of their chlorine, bromine and iodine derivatives, are described. Forty-eight substances were examined and of these thirty yielded the sulphydrated hydrate. The general

formula of these hydrates is $M+(H_2S)_2+(H_2O)_{23}$; that is, they are composed of two hydrogen sulphide hydrate groups, in one of which a molecule of ether has replaced one of water. The crystalline form of all these hydrates is the regular octahedron. In the second chapter the tension of dissociation and in the third the heat of formation of these hydrates is discussed. In chapter fourth similar bodies are described obtained with hydrogen selenide.—*Ann. Chem. Phys.*, V, xxviii, 5, Jan., 1883. G. F. B.

5. *On Brominated Carbon compounds produced in the Bromine manufacture.*—DYSON has examined a liquid obtained as a bye-product in the bromine manufacture. It distilled almost entirely between 82° and 172°, leaving some crystals of carbon tetrabromide in the flask. On fractioning, the main portion distilled over at 148°–150° and consisted of bromoform. The next largest fractions boiled from 121°–123° and from 123°–125°. They consisted of chlorobromoform, $CHBr_2Cl$, giving on analysis 75·97 per cent of bromine and having a vapor density of 105·8, while theory requires 76·76 and 104·2 respectively. Its specific gravity at 20° was 2·477. Bromoform and carbon tetrabromide have been before observed as bye-products by Hermann and Hamilton. But the author thinks this is the first discovery of chlorobromoform in bromine.—*J. Chem. Soc.*, xliii, 36, Feb., 1883. G. F. B.

6. *Change in the double refraction of quartz produced by electrical forces.*—It is proved by W. C. RÖNTGEN that the double refraction of quartz may be modified by placing it in an electric field. It increases if one end of the secondary axis, which becomes negatively electrified under pressure transmitted along this axis, is electrified positively and the other end electrified negatively. The double refraction is diminished when this distribution of charges is reversed. No change in double refraction was observed when the electric forces acted in the axis of no piezoelectricity—at least with the electric field employed by the author. The axes of no piezoelectricity are defined.—*Ann. der Physik und Chemie*, No. 2, pp. 213–233, 1883. J. T.

7. *Optical behavior of quartz in an electrical field.*—A. KUNDT confirms the results of Röntgen upon the change of the double refraction in quartz due to electrical stress. Figures are given which show the action of electrical stress upon the optical phenomena. The compressive and dilative effects in hemimorphic crystals placed in an electrical field can be explained by the piezoelectric effects noticed in such crystals.—*Ann. der Physik und Chemie*, No. 2, pp. 228–233, 1883. J. T.

8. *Magnetic storms.*—M. MASCART has communicated to the French Academy the information that the great magnetic storm of November 17, 1882, was also observed at Cape Horn. According to M. LeCannellier, one of the officers attached to the mission, the storm began at five o'clock on the morning of November 17th and attained its full force during the following night. The declination changed 40′ in three hours and the two components underwent variations of the same order. Comparing these observa-

tions with those of M. Renou, taken at the Observatory of Parc Saint Maur and allowing for the difference of longitude, it is seen that the principal perturbation took place at the two places at the same time.—*Comptes Rendus*, p. 329, Jan. 29, 1883. J. T.

9. *Comet of* 1882.—In the Comptes Rendus of Sept. 25, 1882, M. THOLLON and M. GOUY gave the results of their observations upon this comet, and, by means of a spectroscope of one prism, proved that the sodium lines seen in the spectrum of the comet were displaced by an amount equal to one-quarter or one-fifth of the interval between the two sodium lines; and hence they concluded that the comet was receding from the earth with the velocity of 61^{km} per second. The late astronomical calculations of M. Bigourdan give 76^{km} as the mean velocity of recession. The near agreement of the two results appear to prove the accuracy of the spectroscope method of measuring the recession or approach of the heavenly bodies.—*Comptes Rendus*, p. 371, Feb. 5, 1883. J. T.

10. *The magnetising function of Steel and Nickel.*—Considerable diversity exists between the results of various observers upon the magnetic permeability of the magnetic metals. HUGO MEYER gives results obtained with weak magnetising forces. His method of experiment was to make the steel or iron cylinder the core of an earth inductor and to use the earth magnetic field. His observations lead him to conclude:

(1.) The magnetising function has a positive value for a diminishing magnetising force.

(2.) It increases at first with the magnetising force.

(3.) It increases for weak magnetising forces with the temperature.

The value of $k=2{\cdot}24$ for a magnetising force of $f=3{\cdot}096$ was obtained for pure nickel. Meyer believes that the latter result agrees fairly well with that obtained by Rowland for cast nickel when the difference between the magnetising force employed by the two observers is considered.—*Ann. der Physik und Chemie*, No. 2, pp. 233–253, 1883. J. T.

11. *Determinations of the Ohm.*—Professor G. CAREY FOSTER communicated to a meeting of the Physical Society held in London, January 27, a paper on a new method of determining the ohm which he had proposed in 1874. This method consisted in balancing the electromotive force set up in a coil spinning in the earth's magnetic field, through a wire by means of an opposing electromotive force from a given battery. The two opposing circuits through this wire R are composed, the first of the spinning coil and a zero galvanoscope, and the second of a battery and an absolute galvanometer; these two circuits meeting at the end of the wire R. By this method the values of 1·003 and ·999 were obtained in two trials. Further experiments will be made with increased precautions. Mr. Glazebrook called attention to the agreement between the results of Lord Rayleigh's determinations and his own independent ones. Lord Rayleigh's results are

·9893, ·9865, ·9868, and Mr. Glazebrook's is ·9866 or the mean of Lord Rayleigh's results. He also announced that the Cavendish laboratory, Cambridge, would soon be in a position to test and certify any resistance coils sent there. G. Lippman proposes an electrodynamic method for the determination of the ohm. This resembles Loreng's method. A coil is spun inside a long coil through which a given current is passing. The resistance to be determined is placed in the circuit of the latter coil. The electromotive force produced by the rotation of the inner coil is balanced along the given resistance by the electromotive force in the outer coil. By using a very long outer coil the calculation can be simplified.—*Nature*, Feb. 8, 1883; *Comptes Rendus*, pp. 1348–1350, Dec. 26, 1882. J. T.

II. Geology and Natural History.

1. *Palæo-geological and Geographical Maps of the British Islands and the adjoining parts of the Continent of Europe*; by Edward Hull, Director of the Geological Survey of Ireland. Roy. Dublin Soc., 2d ser., i, 257, 4to.—The fourteen maps which Professor Hull has here published represent the probable geographical and geological condition of northwestern Europe and Britain during successive eras from the "Laurentian," until the era of submergence after the era of the great glacier. They make a highly instructive series, interesting to the general geologist as much as to the European. The maps are accompanied by forty pages of text reviewing the facts which the maps illustrate. On the map of the Glacial period, the British area is wholly emerged and all under ice except the southern part of England, south of a line running across from the southwest corner of Wales to a point on the west coast, north of the Thames; that of the submergence 1,350 feet in N. Wales, etc. which followed, represents the British area as an archipelago, Ireland about five-sixths water, England four-fifths, and Wales and Scotland less than two-thirds; and that of the so-called Upper Glacial, or epoch of sub-glacial conditions, as about a fourth less under water than in the area of greatest submergence.

2. *The Geological Survey of Pennsylvania.*—The following volumes have recently been issued. *The Geology of Bedford and Fulton Counties*, by J. J. Stevenson. No. T2, 382 pp. 8vo, with two maps. Harrisburg, 1882. *The Geology of Pike and Monroe Counties*, by I. C. White; and *Special Surveys of the Delaware and Lehigh Water Gaps*, by H. M. Chance. No. G6. 408 pp. 8vo; with colored geological maps, a map of glacial scratches and sections, illustrating Mr. White's Report. 1882.

The Geology of Philadelphia County and of the southern parts of Montgomery and Bucks; by Charles E. Hull, with analyses of rocks, by Dr. F. A. Genth and F. A. Genth, Jr. No. C6. 146 pp. 8vo, with a colored geological map. 1881.

A further notice is deferred.

3. *Report on the Geological Survey of Ohio:* Zoology and Botany. Part I, Zoology; consisting of a Preface by Professor J. S. Newberry; Report on the Mammals, by A. W. Brayton (185 pp.); on the Birds, by Dr. J. M. Wheaton (442 pp.); on the Reptiles and Amphibians, by Dr. W. H. Smith (106 pp.); on the Fishes, by Dr. D. L. Jordan (268 pp.). 8vo. Columbus, 1882.

4. *United States Geological Survey.*—The Congress, whose term has just expired, with commendable liberality appropriated for the Geological Survey a total sum of $341,140. This applies to the fiscal year beginning July 1, 1883 and ending June 30, 1884. The appropriation for the current fiscal year was $258,440, so that the provision for the coming year is on a much more liberal scale. The Bureau of Ethnology, which is likewise under the direction of Major Powell, had its appropriation raised from $35,000 to $40,000.

5. *Geological Survey of Alabama.*—The legislature of the State of Alabama has recently appropriated the sum of $50,000, to carry on the Geological Survey for the next ten years. It is proposed to devote the greater part of the work to the coal-fields, and to the region of the iron ores, since these, especially the former, have been hitherto almost untouched. During the past ten years the State Geologist has been obliged to work with only $500, and the present increase in the appropriation, although not as great as might have been desired, will make it possible to extend the work to a very important degree.

6. *Equivalency of the Lime Creek beds of Iowa;* note by H. S. Williams.—Since my paper, at page 97 of this volume, was published, I have learned that I was wrong in speaking of the rocks of Lime Creek, Iowa, as referred by western geologists to the Kinderhook group. How I was led astray by publications on the subject it is not important here to explain. I still hold it true that the exact relation of the Lime Creek beds to other deposits of the west is not satisfactorily determined, and that its fauna is represented in New York at the very base of the Chemung formation.

7. *Chondrodite and Humite.*—H. Sjögren has recently published the results of an investigation of two minerals of the chondrodite group from Sweden. It will be remembered that Scacchi originally described the Vesuvian humite as existing in "three types;" later it was shown that they were distinct minerals, though closely related; type I is orthorhombic and is now called *humite*, type II is monoclinic and is called *chondrodite*, type III is monoclinic and is called *clinohumite*. The crystals from Brewster, N. Y., have been shown to be chiefly chondrodite, though humite and clinohumite also occur sparingly. The crystals described by Sjögren from the Ladu mine, Wermland, Sweden, are holohedral orthorhombic and correspond to humite (type I) of Vesuvius; those from Kafveltorp belong to the species chondrodite as now defined. The crystals from the latter locality have been subjected to a thorough investigation by Sjögren (Lund

Univ. Års-skrift, xvii), who gives the results of many measurements and about sixty figures, showing the variety in form, the optical structure and so on. The measured angles agree closely with those of the Vesuvian chondrodite, less so with that from Brewster, and the optical constants are also nearer the former. The Kafveltorp mineral is also near the Vesuvian in the frequency with which the polysynthetic twin structure is observed, giving rise to much apparent irregularity in the angles.

8. *Arboretum Segrezianum: Icones Selectæ Arborum et Fruticum in Hostis Segrezianis Collectorum*, etc. Auct. ALPHONSE LAVALLÉE.—Two years ago we gave a short notice of the fasciculi, then published, of this admirable work. Two more have now reached us. The publication does not advance rapidly, but it will be understood that the work is in no respect of a commercial character, is the outcome of pure scientific devotion, and is of high critical character. Its author possesses and delights in the best collection of hardy shrubs, in a scientific point of view, that is now known. These livr., 5 and 6, carry the letter-press from page 65 to page 108, and the plates represent three species of *Pterocarya* (Trans-Caucasian and Chinese); two of our Atlantic U. States species of *Cratægus*, and one of the Old World; *Calycanthus floridus*, a variety with ovate leaves; *Actinidia volubilis* of Japan; *Schizandra Chinensis* Baill.; *Akebia quinata*, another Chino-Japanese climber, which is already well known in cultivation in the United States; *Clematis orientalis*, L., to which the author has reduced the Himalayan *C. graveolens*, Lindl., a species which we cultivate as far north as Canada, being perfectly hardy, in fruit ornamental, but the blossoms dull. Much may be expected from M. Lavallée's study of the species of *Cratægus* from the life. We were quite prepared to recognize *C. punctata* as a good species. We do not understand how the "*C. coccinea*, var. *cordata*," with its large flowers and large fruit, can be of the Linnæan species of that name; and we think it quite certain, on the authority of the original specimen, that the "*C. leucophlœus*, Mœnch," figured on tab. 22 *is* the *C. tomentosa* of Linnæus.

A. G.

9. *Color and Assimilation.* — TH. W. ENGELMANN has made an extensive use of the so-called Bacteria-method for investigating the effect of light on chlorophyll cells. In the Botanische Zeitung for January 5 he gives further details of his experiments and presents some of his conclusions. The effect of free oxygen upon quiescent bacteria is so great that by their presence the trillionth of a milligram of the gas can be detected. When a green cell in water is evolving oxygen, even in an extremely minute amount, the movements of the bacteria afford instantaneous indication of its presence. Moreover, when the ray of light, shining through or on the green cell, is unfavorable to the process of assimilation and the evolution of oxygen, the effect on the bacteria is at once shown. All of Engelmann's experiments were checked by control-observations, and appear to have been

conducted with care throughout. The results are mainly as follows: Only those cells which contain particles of colored protoplasm evolve oxygen in the light. When colorless protoplasm was screened by a colored solution, or was illuminated by light coming through a green leaf, no oxygen was evolved. It will be seen that this has a direct bearing upon some of Pringsheim's views. In the case of cells of different colors, e. g., Green, *Sphagnum* and *Spirogyra*, Yellowish-brown, *Navicula* and *Pinnularia*, Bluish-green, *Oscillatoria* and *Nostoc*, Red, *Callithamnion* and *Ceramium*, distinct relations between the color and the amount of assimilation under different rays were made out. The maximum activity for green cells was in the red between B and C (the place of the most striking of the chlorophyll absorption bands); for yellowish-brown, in the green, at D½E; for bluish-green, in the yellow; for red, in the green. Hence, there must be a series of colors other than that of chlorophyll which possess the power of assimilation in different parts of the spectrum. The maximum activity for a given color is found in rays complementary to that color. The author gives also an account of the possible bearing of the above on the distribution of organisms at different depths of water. G. L. G.

10. *On the Influence of Sunny and Shaded Localities on the Development of Foliage Leaves;* by E. Stahl (of Jena), (Zeit. f. Naturwissensch., XVI. N. F. IX, 1, 2. Also separately.)—Haberlandt, in an examination of the comparative anatomy of the assimilating tissues in plants, has come to the conclusion that light is almost without influence in governing the shape of leaves or the arrangement of the chlorophyll cells. On the other hand, Pick has shown that the shape and arrangement of assimilating tissues are certainly controlled to some extent by the presence of full sunlight or of shade. Both of the foregoing works were preceded by a paper by Stahl in which the influence of the intensity of light on the structure and arrangement of chlorophyll-parenchyma was pointed out. It may be further stated that the same author had previously studied the effect of the direction and intensity of light on some movements in plants. In the paper just published he incorporates some of the results earlier attained by him, and adds several facts of considerable interest. The thesis may be stated as follows: The elongated, or palisade cells, are best adapted for light of high intensity; the looser parenchyma for that of low intensity. (To this, in passing, may be added Areschoug's observation that the looser or spongy parenchyma is that best adapted for transpiration and characterizes the foliage of moist climates; where either local or climatic relations render too rapid transpiration undesirable, these layers are protected by a palisade system.) The author has devoted most attention to plants which can endure shade as well as bright sunlight, and here wide differences are alleged to exist between the forms growing in light and those found in shade. All the differences are of the character above described, namely, adaptation to

sunlight by the development of a better palisade system. The critical point of the investigation is plainly that leaves developing in sunlight have a less well-characterized spongy parenchyma, and a better marked palisade system. In view of the fact that these two systems are generally found as stated in the thesis, the author asks whether this ought not to influence our treatment of plants in green-houses. The paper and its illustrations are of great interest. G. L. G.

11. *Rabenhorst's Kryptogamen-Flora*, vol. II, parts 1–3.—We have already noticed in this Journal the earlier numbers of the first volume of this work, and now the first three parts of the second have just appeared containing the first part of the Marine Algæ by Hauck. The marine flora of Germany proper is, of course, of comparatively small account, being confined principally to species from Heligoland and the Baltic; but the Austrian species are numerous and interesting, and Hauck, who resides at Trieste, has had the great advantage of being able to study them on the spot. After a few pages devoted to a description of the manner of collecting and preparing specimens, there follows an account of the classification of the *Florideæ*, which are considered to form an order, the name family being applied to the divisions as *Porphyraceæ*, *Corallinaceæ*, etc. The parts already issued include the *Porphyraceæ*, *Squamariaceæ*, *Hildenbrandtiaceæ*, *Wrangeliaceæ*, *Helminthocladiaceæ*, *Chætangiaceæ*, *Ceramiaceæ*, *Spyridiaceæ*, *Cryptonemiaceæ*, *Gigartinaceæ*, and part of the *Rhodymeniaceæ*. The arrangement is, in general, that of J. G. Agardh as modified by the writings of Thuret and Bornet. The departure from previous classifications is most marked in the *Rhodymeniaceæ*, in which are included *Chylocladia* and *Chryshymenia*. In the first named genus is included our common *Champia parvula* Harv., and the *Chylocladia Baileyana* of our coast is merged in *C. uncinata* Menegh., to which no exception can be taken. Another innovation is the union of *Centroceras* with *Ceramium*, which also seems warranted.

The descriptions and synonymy are excellently managed by Hauck, and are accompanied by an astonishing number of good wood-cuts, principally after Thuret and Bornet and Kuetzing, the structure of the frond and fruit in each genus being figured, and in case of large genera, such as *Callithamnion*, several figures are given. There are besides three full-page photo-lithographs of *Corallineæ*. Altogether the work promises to be a model, and to furnish what has long been a desideratum, viz: a complete guide to the marine Algæ of the Germanic nations. To American students it will be especially welcome, as the numerous illustrations and excellent descriptions are furnished at a price within the reach of those who cannot afford to buy the larger illustrated works. W. G. F.

12. *Heterœcism of the Uredines;* by CHARLES B. PLOWRIGHT.—In two very interesting and important papers published in Grevillea and the Gardeners' Chronicle, for 1882, Mr. Plowright gives

his experiments on the connection of certain æcidial and teleutosporic forms of *Uredines*. His experiments were started in 1881 with cultures of the spores of *Æcidium Berberidis* on wheat; but as *Uredo linearis*, which is the uredo-stage of *Puccinia graminis*, appeared on the control plants as well as on those on which the æcidial spores were sown, he was not able to confirm the connection between *Æcidium Berberidis* and *Puccinia graminis* which is accepted by continental botanists. In 1882 he repeated his experiments on a larger scale and with a more satisfactory result. In the case of *Puccinia graminis*, the blight in grain, he not only succeeded in producing *Uredo linearis* on wheat by sowing the æcidial spores, the control plants remaining healthy, but he reversed the experiment and produced *Æcidium Berberridis* by sowing the *Puccinia* spores. He also sowed the spores of *Podisoma Sabinæ* and *P. Juniperi* on pear and Cratægus seedlings and produced *Rœstelia cancellata* and *R. lacerata*, respectively. The spores of *Gymnosporangium Juniperi*, sent from a distance of several hundred miles, when sown on *Sorbus Aucuparia* were followed by a growth of *Rœstelia cornuta*, a species never before seen by Plowright in Norfolk, where the experiment was made. He also experimented with other species of *Puccinia*, *Peridermium* and *Uromyces*, and succeeded in confirming the views of continental writers as to their secondary forms, in one instance producing a *Puccinia* not before known in Britain, and in the case of *Uromyces Junci* showing the relation to *Æcidium zonale* which was suspected by Fuckel.

No writer, since DeBary, has shown more successful results in this difficult subject, and Plowright deserves great praise for his careful experiments. Except in one series of cultures the fully developed æcidial form was obtained, and not the spermagonia alone, as had been the case with some other investigators. Although most of the experiments were rather in confirmation of those of other botanists, in a very important respect he has added to our previous knowledge. One great difficulty in the way of accepting the connection between *Æcidium Berberidis* and *Puccinia graminis*, especially in this country, has been that the *Puccinia* is very common in districts where the barberry is unknown, and according to DeBary the *Puccinia* spores cannot be made to germinate and grow upon grasses. Plowright, however, was able, in a limited number of cases, to make the *Puccinia* spores grow upon wheat, especially on young seedlings. Accepting this statement one can see how, in our Western States, the wheat blight could be propagated from year to year without the presence of barberry bushes. In this connection it is of interest to know the details of the provincial laws of Massachusetts relating to the enforced destruction of barberry bushes, in consequence of their supposed injurious influence on the grain crops. DeBary states that such laws existed, following the account of a German traveler, Schoepf. Through the kindness of Professor J. B. Ames, of the Harvard Law School, I have been

able to examine the laws on the subject. They are to be found in the Province Laws of Massachusetts, 1736–1761, p. 153, Anno Regni Regis Georgii II., Vicesimo Octavo, Chap. X, published Jan. 13, 1755. It is entitled, "An Act to prevent Damage to English Grain arising from Barberry Bushes." After a preamble stating that "it has been found by experience that the blasting of wheat and other English Grain is often occasioned by Barberry Bushes to the great loss and damage of the inhabitants of this province," there follows the enactment of the law, in six sections, in which owners of land containing barberry bushes are ordered to destroy them before June 13, 1760; and, if they do not do so, any person, after giving a month's notice, is at liberty to destroy the bushes and recover the cost of so doing from the owner of the land. Also surveyors of highways are ordered to cut down all barberry bushes growing on public land under penalty of a fine for non-performance. There are also several stringent regulations showing the importance attributed to the subject by the Government at the time. The act was to continue in force until June 10, 1764. W. G. F.

13. *Anatomical Technology as applied to the domestic Cat, an introduction to human, veterinary and comparative anatomy;* by BURT G. WILDER and SIMON H. GAGE. 8vo, 575 pp. with 130 cuts and 4 plates. A. S. Barnes & Co., New York and Chicago, 1882.—This is intended as a manual for use in laboratories of comparative anatomy, and will undoubtedly supply a want long felt by very many teachers. A large amount of space (148 pages) is devoted to introductory matters, such as descriptions of instruments and their use; preparation and preservation of specimens; the metric system; terminology; directions for injecting the vessels; "slip system of notes" (7 pages), etc. Most of this will doubtless be of help to beginners, and some of it to teachers as well, but some matters usually found in school books and dealers catalogues might have been omitted without much detriment to the general usefulness of the book, as an anatomical manual. The portion of the book relating specially to the anatomy of the cat contains descriptions of the brain, cranial nerves and sense-organs (130 pages, including a description of the amphibian brain) of the vascular and general nervous system; of the abdominal and thoracic viscera; of the skeleton; and of certain portions of the muscular system (fore-leg). At the end there is a list of the works cited. At first sight there seems to be a large number of new or unfamiliar technical words and expressions, some of which have no apparent advantage over those in common use. We do not see the advantage of saying of a cat, laid on its back, that it is "placed dorsicumbent." Nor does "dorsiduct the tail" seem to have any very striking advantage. But many of the reforms in the nomenclature of organs and parts seem to be judicious as well as useful. V.

14. *Mémoires concernant l'Histoire Naturelle de l'Empire Chinois par des Pères de la Compagnie de Jésus.* I cahier. Chang-

Hai: quarto, 55 pp., 12 plates.—This number contains two memoirs. The first is on *Trionyx*, illustrated by 10 lithographic plates, by P. M. Heude. Thirteen species are described. These are referred to nine genera, viz: *Yuen* (five species), *Psilognathus*, *Temnognathus*, *Gomphopelta*, *Cœlognathus*, *Tortisternum*, *Ceramopelta*, *Captopelta*, *Cinctisternum*. The second memoir, entitled, Étude sur le *Coccus pé-la*, is by G. Rathouis. It is illustrated by two plates, showing both sexes and their transformation, with some anatomical details. We understand that this work is to be continued. V.

III. Astronomy.

1. *Astronomical Papers of the American Ephemeris;* Vol. I. Washington, 1882.—This is the completed volume containing six papers, some of which have been heretofore distributed in separate form. The object of the series is stated to be a systematic determination of the constants of astronomy from the best existing data, a re-investigation of the theories of the celestial motions, and the preparation of tables, formulas and precepts for the construction of ephemerides. Four of the papers are by the superintendent, Professor Newcomb: Recurrence of Solar Eclipses, with tables of eclipses from B. C. 700 to A. D. 2300 (this Journal, xx, 79); a transformation of Hansen's Lunar Theory compared with the theory of Delaunay; Catalogue of 1098 standard clock and zodiacal stars; and a Discussion of observed Transits of Mercury. The two remaining papers are, An Experimental Determination of the Velocity of Light, by A. A. Michelson, and Gauss's method of computing secular perturbations, with an application to the action of Venus on Mercury, by G. W. Hill.

2. *Transits of Mercury* 1677–1881.—The sixth of the above papers, by Professor Newcomb, is an exhaustive discussion of all the transits of Mercury hitherto observed. An interesting portion of the discussion is that referring to the possibility of an inequality in the earth's rotation on its axis. Professor Newcomb had found that the moon's mean motion for about 250 years could be represented with approximate accuracy by the addition of a single term with a period not differing greatly from 300 years. Taking as the standard of time the earth's axial rotation between 1750 and 1850, and assuming that the observed inequalities in the moon's mean motion are to be accounted for by actual inequalities in the earth's rotation, then our measurements of time would be in error by amounts ranging from 17 seconds in one direction to 17 seconds in the other direction, between 1723 and 1881. Inequalities of such an amount could not fail to be indicated by the observations of the transits of Mercury. If we are required to choose between a uniform axial rotation and one varying sufficiently to account for the above inequality in the moon's mean motion, the observations of the transits make the former by far the most probable. But the transits of Mercury do show a remarkable inequality of the required kind but only one-

third its amount. If it could be supposed possible that the moon's mean motion and the earth's axial rotation varied together, the observations of the moon and of Mercury's transits would be together satisfied. But in any case Professor Newcomb concludes that inequalities in the moon's mean motion not accounted for by the theory of gravitation really exist, and exist in such a way that the mean motion of the moon between 1800 and 1875 was really less than it was between 1720 and 1800.

The discordance between the observed and the theoretical motions of the perihelion of Mercury, first pointed out by Leverrier, is also the subject of special discussion by Professor Newcomb. He concludes that this really exists, and is indeed larger than Leverrier supposed. The observed centennial motion of the perihelion of Mercury is greater by 43 seconds than the theoretical motion computed from the best attainable values of the masses of the planets. In speculating upon the possible causes of this excess of motion, Professor Newcomb says, "The most simple hypothesis is the well-known one of Leverrier, which presupposes the existence of a planet or group of planets between Mercury and the sun. That any such body or bodies of sufficient mass to produce the motion in question can really exist seems to be out of the question, for a number of reasons.

"In the first place, on any probable hypothesis of the relation of mass to reflecting power, it is impossible that a planet or group of planets of sufficient mass to produce the observed motion of the perihelion of Mercury could exist without being very conspicuous objects during total eclipses of the sun, if at no other time. We cannot, indeed, assign an exact value to the mass unless we know the mean distance. But the less we suppose the mean distance, and therefore the greater we suppose the liability that the planet should be lost in the sun's rays, the greater the mass required and the more brilliant the planet or planets would shine during a total eclipse. In fact, the more distant from the sun the required planet, the less readily it would be detected during an eclipse; but, on the other hand, it would be more readily detected at other times. In a paper published in Gould's Astronomical Journal, volume vi, the writer showed that if a group of sufficient magnitude existed, the transits over the sun would be too frequent to escape detection.

"In the next place, no such group could exist and produce the observed effect without also disturbing the secular motions of the node of Mercury and Venus. It was shown in the paper just referred to that, supposing the group to lie in the ecliptic, the excess of motion of the node would be as great as that of the perihelion. But observations do not indicate any such excess. If, therefore, the group exists its plane must be very nearly coincident with the orbit of Mercury. But here we meet with two difficulties:

"If the mean plane of the group were at any epoch coincident with that of Mercury, it could not remain so permanently, but the planes of the different orbits would, in time, group themselves

near the invariable plane of the planetary system. Again, if the coincidence had place with the orbit of Mercury it could not have place with reference to the plane of Venus, and the plane of motion of that planet would be subject to a secular variation.

"Now it is quite true, as already pointed out, that these several secular motions of the planes have not been investigated with such thoroughness that we can speak positively on this question. At the same time it appears extremely improbable that any disturbing action can exist of such magnitude as the hypothesis would imply.

"The hypotheses just considered are those of a single planet or a group of planets. It may be asked to what limit we must suppose the subdivision carried in order that the individual bodies may escape detection. The reply is that they must be so small as to be invisible either in transit across the sun or by reflected light during a total eclipse, or in the evening after sunset. Their diameters at the distance unity cannot, therefore, exceed a very small fraction of a second.

"The limit of mean diameter may be roughly placed at $\frac{1}{80}$ that of the earth, and the limit of individual volume at $\frac{1}{100000}$ that of the earth. Since the total mass must be an appreciable fraction of the mass of the earth the number of the hypothetical planets must be thousands and probably tens of thousands.

"It may be suggested that in the zodiacal light we have evidence of at least the possibility that a group of many thousand bodies, too minute to be visible to the naked eye, circulate between the earth and the sun. It would be an interesting photometrical investigation to ascertain the limit of volume of these bodies on the supposition that they are of ordinary whiteness. The extreme softness of the zodiacal light is such that the minimum number of separate bodies would have to be estimated at hundreds of thousands. The writer thinks it probable that the result would be that a collection of 100,000 bodies with a combined volume one-tenth that of the earth would glow with a much brighter light than the zodiacal light actually does. The hypothesis of the zodiacal light is subject to the same difficulties with respect to motions of the nodes as have already been pointed out with respect to the group of planets. But we have at present no way of positively disproving it.

"We may next inquire whether either a possible ellipticity of the sun or of his atmosphere, or of the matter in his interior, can produce the observed effect. The reply to this would be that the most exact measures have failed to show any ellipticity of the body of the sun at all approaching that required. Indeed, if we suppose the elliptic disturbance of matter, if I may use the expression, to be within the sun, it would probably be found that the consequent deviation of the level surfaces at the photosphere from a spherical form would lead to a sensible ellipticity of the sun's disk.

"There is a field for investigation in the question what the mass of a ring round the sun must be to produce the observed effect, and what influence that mass would have upon the motion of the nodes of Mercury and Venus. This is a question which can be

more profitably discussed when the character of the phenomena is more accurately ascertained. But, as the question now stands, all hypotheses that the observed phenomenon is produced by the attraction of unknown matter in the neighborhood of the sun or Mercury must be dismissed as at least highly improbable.

"We may next inquire whether any deviation from or modification of the law of gravitation which would produce the observed effect is admissible. The most natural modification of this kind would be the addition of a term varying as the inverse third or fourth power of the distance. This hypothesis can, however, be refuted very readily. A term of the inverse third power which, at the distance of Mercury, should have a value even the millionth part of the total gravitative force of the sun would, at the distance of a foot, have a value two hundred thousand times that of the term depending on the inverse square. If higher powers than the cube were added the discrepancy would be yet more enormous. The existence of a term of such magnitude is out of the question."

"Another hypothesis which has been considered in this connection is that of Weber's electro-dynamic theory. According to this theory the gravitative force between two bodies is expressed by an equation of the form

$$\frac{m}{r^2}\left(1-\frac{1}{h^2}\left(\frac{dr}{dt}\right)^2+\frac{2r}{h^2}\frac{d^2r}{dt^2}\right)$$

in which the constant h, as is evident from the formula, must be a velocity. This velocity Weber has sought to determine experimentally; his value is 439,450 kilometers per second. From this datum Tisserand has computed the secular variations of the planets. (Comptes Rendus, vol. lxxv, p. 760.)

"His results are that the only element affected with a sensible inequality is the perihelion, and that the secular motions of the perihelia of Mercury and Venus would have the following values: Mercury, $6''\cdot28$; Venus, $1''\cdot32$. If h be the velocity of light, his result is, Mercury, $13''\cdot65$; Venus, $2''\cdot86$.

"But the actual motion has been found to be three times this. To produce this motion the value of h must be reduced to about 174,000 kilometers per second. Objections have been raised to Weber's whole theory on the part of physicists, to whom the discussion of its possibility must be left."

Obituary.

Henry Seybert, an early worker in American Mineralogy, died March 3d, 1883. He contributed analyses of molybdenite from Chester, Pa., chromite, tabular spar, pyroxene, colophonite, chrysoberyl of Haddam, chondrodite of N. J.; and in the latter he independently discovered fluorine. He analyzed in 1830 the Tennessee meteorite described by Bowen. His father, Adam Seybert, was, like the son, a graduate of the École des Mines of Paris, and one of the earliest original investigators in chemistry in this country. Dr. Seybert's ample fortune is said to be distributed in various endowments, chiefly of chemistry.

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[THIRD SERIES.]

ART. XXXII.—*Observations of the Transit of Venus, Dec.* 6, 1882, *at Princeton, N. J., and South Hadley, Mass.* (Communicated by Professor C. A. YOUNG.)

I. STATIONS.

THE observations of the Transit of Venus in Princeton were made at three different points: at the observatory of the John C. Green School of Science, at the Halsted Observatory, and at the private observatory of Dr. S. Alexander.

The *astronomical* latitude and longitude of the first-named station are, respectively, 40° 20′ 57″·8, and 9^m 34^s·54 east of Washington. Its *geodetic* lat. and long. are 40° 20′ 54″·0, and 74° 39′ 16″·9 west of Greenwich, determined by reference to a neighboring Coast Survey station, and using Clark's spheroid. The Halsted Observatory is 1″·98 south and 29″·06 west of the S. S. Observatory, and Dr. Alexander's station was about 400 feet northeast of the Halsted Observatory.

The observatory at South Hadley is in latitude 42° 15′ 18″·2, and its approximate longitude is 18^m 05^s·0 east from Washington.

II. TIME.

The time used at Princeton was that of the standard sidereal clock of the S. S. Observatory. The beats of this clock are communicated electrically to every room in the building, and to the Halsted Observatory, and were used directly by all the observers, except Dr. Alexander. The error of the standard

clock was determined by Mr. McNeill with the Transit instrument on the evenings of both Dec. 5th and Dec. 6th. We also received the Washington noon signals on the 5th and 6th; and after correcting them for the errors of the Washington clock (obligingly communicated to me by the Superintendent of the Naval Observatory), the accordance between the results of these signals and the star observations was complete within $0^{s}\cdot03$. At local mean noon on Dec. 5th, the clock was slow $14^{s}\cdot88$, and gaining $0^{s}\cdot030$ hourly. A mean-time clock, in the same room with the sidereal, was kept in continual comparison with it, both of the clocks recording their beats upon the same chronograph sheets all through the Transit.

III. Observers and Instruments.

1. Dr. S. Alexander, Professor Emeritus of Astronomy. This gentleman used a 3½-inch telescope by Fraunhofer, equatorially mounted. The eye-piece was an erecting one with a power of about 80, and a thick, neutral-tint shade glass. Dr. Alexander took his time from a mean-time chronometer, which was compared with the observatory clock before and after the observations.

2. Professor C. A. Young, in the Halsted Observatory. The instrument was the great 23-inch equatorial of 30 feet focus, with a polarizing helioscope, the first reflecting prism of which is hollow and filled with water circulating through it. The magnifying powers used in the observation of the contacts was 160. At the two internal contacts the aperture was reduced to 5¼ inches, in order to make the observations comparable as far as possible with those of the various government expeditions. At the external contacts and during all the micrometric and spectroscopic observations the full aperture was employed.

3. Professor C. G. Rockwood, also in the Halsted Observatory. He used a dialytic telescope of 4 inches aperture belonging to himself; it was equatorially mounted, and had the usual reflecting solar eye-piece with magnifying power of 113.

4. C. I. Young (son of Professor Young). His instrument was the finder of the great equatorial; aperture 5 inches; reflecting solar eye-piece with power of 109.

At the School of Science Observatory there were six observers, viz:

5. Professor C. F. Brackett (in charge of the photographic operations). He observed the contacts with the equatorial of the S. S. Observatory; aperture 9½ inches, which was reduced to 5¼ inches at all the contacts except the first. The eye-piece was a Merz polarizing helioscope, with magnifying power of 164.

6. M. McNeill, Instructor in Astronomy. His instrument was an equatorial mounted on a post in the open air. Aperture 4 inches; reflecting eye-piece with power of 162.

7. Professor W. Libbey, Jr. Portable equatorial of 3 inches aperture; reflecting eye-piece and power of 96.

8. W. F. Magie, Instructor in Physics. He used the finder of the 9½-inch equatorial. Aperture 3 inches; reflecting eye-piece and power of 124.

9. H. Crew, Fellow of the College. His instrument was an altazimuth of 3 inches aperture, reflecting eye-piece, power 80.

10. H. L. Baldwin, student. Altazimuth of 3 inches aperture, with reflecting eye-piece and power of 80.

In addition to these observers, two squads of students, eleven in all, observed images of the sun thrown upon screens by a 9-inch Newtonian reflector and a 5½-inch comet seeker. The results, however, are hardly satisfactory enough to be given here, though they will be published in another connection at some future time.

At South Hadley, the third and fourth contacts were observed by Mr. R. F. West, a graduate student of astronomy in Princeton, who was sent (by the liberality of Professor Libbey), to utilize the fine instruments of Mt. Holyoke Seminary, an institution with which the writer has been long connected as a lecturer. The telescope is an 8-inch equatorial by Clark. The whole aperture was used, with a reflecting eye-piece and magnifying power of 175.

The local time at South Hadley was determined by transit-instrument observations on Dec. 6th and 7th, and the approximate longitude by time-signals received at the telegraph office from Cambridge on Dec. 5th and 6th, and compared with the observatory clock by means of a box chronometer carried about a thousand feet. Unfortunately the performance of the chronometer during its short journeys was unsatisfactory, and the resulting longitude is doubtful by the amount of one second at least, and possibly two. The latitude was determined by the writer a year ago, by the zenith telescope method.

For three or four weeks before the Transit all the observers had practiced with an artificial transit as opportunity offered.

IV. Weather.

At Princeton, at the time of the first contact, there were numerous thin clouds, near the ground and flying rapidly, so that observers only a few rods apart were quite differently affected. At the second contact it was clearer; at the third the clouds were very troublesome; and at the fourth it was clearer again. The temperature was between 40° and 45° F.,

all through the Transit, and there was a fresh breeze from the southwest. The seeing was generally very good as regards distinctness, though after noon it was less satisfactory.

At South Hadley thick clouds prevented all observation of the first two contacts; then occasional breaks appeared between the clouds, and at the end of the Transit it was clear, though the seeing was very bad and unsteady.

V. Observations of Contacts.

We present the observations in tabular form, each contact by itself:

Observations of First (External) Contact.

Observer.	Washington Mean Time.	Observer's Remarks.
2. C. A. Y.	20^h 55^m 34^s	Slight hardening of sun's limb suspected at the predicted point.
	55 40	Unmistakable. Contact noted. (*a*)
	55 50	Notch now obvious. 15° or 20° of planet's limb.
3. C. G. R.	56 20	Edge unsteady; numerous notches seen; one of them apparently permanent.
	56 40	Venus clearly on sun.
4. C. I. Y.	55 50	Suspected alteration of sun's edge for some seconds—limb boiling.
	55 58	Disturbance of limb obvious.
	56 02	Edge of planet distinctly seen.
5. C. F. B.	56 30	Planet's whole disc suddenly became visible in contact with sun. 20°—25° of planet's limb. (*b*)
6. M. McN.	56 00	Notch first seen. Sun faint. 20°—25° of planet's limb on sun. (*c*)
	56 40	Planet well entered.
7. W. L., Jr.	55 48	Evident notch. Sun's limb sharp. (*d*)
8. W. F. M.	56 46	Planet first seen. Well on sun.
9. H. C.	56 59	Planet first seen; some distance on sun.
10. H. L. B.	56 34	Indentation first perceived. Definition not very good.

Notes on First Contact.

(*a*.) I think this time of contact cannot be wrong by more than a very few seconds, though it may possibly be a little late. The effect noticed 6 seconds earlier was probably due to the obscuration of the chromosphere. The planet's outline was not seen before contact, and did not become visible to me until some ten minutes later.

(*b*.) Probably at this moment the sun came into a clear space between the clouds.

(*c*.) Mr. McNeill's estimate of 20°—25° of planet's limb on the sun indicates a time of contact closely accordant with my own observation—not more than 4 or 5 seconds later certainly.

(*d*.) Mr. Libbey's observation seems to be an excellent one; all that follow are obviously too late.

None of the observers caught a glimpse of the planet's disc before contact. Mr. Brackett's observation shows that the clouds were the probable hindrance.

OBSERVATIONS OF SECOND CONTACT (INTERNAL).

Observer.	Washington Mean Time.	Observer's Remarks.
1. S. A.	$21^h\ 16^m\ 08^s$	Excessively fine line at angle of contact of the two discs. Possibly early. (*a*)
2. C. A. Y.	15 56·2	Dark limb of planet tangent to sun's limb ideally produced across planet's atmosphere.
	16 06	Planet's atmosphere still projects beyond outline of sun's limb, forming a lump.
	16 18·6	Sun's limb resumes its form—lump vanishes. Contact noted.
	16 26	Contact clearly past. (*b*)
3. C. G. R.	16 24	Limb of sun complete; black drop not very evident; perhaps 2 seconds too early.
	16 30	Sure edge of sun was complete around Venus.
4. C. I. Y.	15 56	Dark fringe between Venus and sun fades into gray.
	16 16	Fringe becomes white.
	16 26	Venus distinctly on sun.
5. C. F. B.	16 15	Black band formed. Apparent geometrical contact.
	16 26	First continuous separation of limbs.
6. M. McN.	16 06	Not on.
	16 19	Light appeared all around planet, yellowish like edge of the sun. Probably about 2 seconds after contact.
	16 31	Planet clearly on sun. (*c*)
7. W. L., Jr.	16 08	At this moment a gray streak took the place of the black ligament between the cusps.
8. W. F. M.	16 30	Shade between limbs of planet and sun became gray.
	16 34	Sure white.
9. H. C.	15 56	First meeting of the two horns.
	16 36	Planet certainly on sun's disk.
10. H. L. B.	$21^h\ 16^m\ 12^s$	Considerable black drop, but breaking of ligament well seen, and almost instantaneous.

NOTES ON SECOND CONTACT.

(*a.*) The original record of Dr. Alexander's observations reads *two minutes* earlier; but he thinks a mistake as to the minute was made by the person who recorded for him.

(*b.*) The planet's atmosphere was finely seen, and embarrassed the observation. For more than 20 seconds it formed a lump projecting from the sun's limb. The seeing was so good that the granulation of the sun's surface was well seen, though there was considerable haze.

(*c.*) Mr. McNeill estimates the time of contact as $21^h\ 16^m\ 17^s$, W. M. T., deducting 2 seconds from the time recorded.

OBSERVATIONS OF THIRD CONTACT (INTERNAL).

Observer.	Washington Mean Time.	Observer's Remarks.
1. S. A.	$2^h\ 30^m\ 49^s$	Very satisfactory—no black drop.
2. C. A. Y.	2 39 27·2	Geometrical contact; apparently not doubtful more than a second or two. Clouds pretty thick. (*a*)
	39 33	Contact certainly past.
3. C. G. R.	39 33	Wind shook telescope; very hazy; not sure that contact was past for 20 seconds more.
4. C. I. Y.	39 12	Contact. Observation through clouds; limbs boiling badly.
	39 34	Cusps now distinctly formed.
5. C. F. B.	39 43	Very narrow gray space between the limbs.
	39 47	Black band connects edges of sun and planet.
6. M. McN.	38 59	Contact—not reliable. Clouds very thick and images very faint.
	39 53	Contact clearly past.
7. W. L., Jr.	39 43	No black drop. Geometrical.
8. W. F. M.	39 47	Black drop clearly seen joining sun and Venus.
9. H. C.	38 34	First suspected contact. (*b*)
	39 04	Certain that contact was over.
10. H. L. B.	39 46	Very little black drop. Sun indistinct through clouds.
	At South	*Hadley.*
11. R. H. W.	$2^h\ 39^m\ 22^s$	Formation of black drop. Geometrical contact at least 10 seconds later.

NOTES ON THIRD CONTACT.

(*a*.) The clouds at the Halsted Observatory were not quite so thick as at the other stations, and this may account for some of the discrepancies. Observers 1, 5, 7, 8 and 10 seem to agree very well upon a time some 10 to 15 seconds after 2 was sure that the contact was past. The planet's atmosphere was invisible to all the observers alike, but at the Halsted Observatory the seeing was fairly steady, and the contact seemed to take place so promptly that the writer felt justified in recording even the fraction of a section.

(*b*.) Query: error of one minute.

The clouds at this contact were more troublesome than at either of the other three, and the observations are probably less reliable.

OBSERVATIONS OF FOURTH CONTACT.

Observer.	Washington Mean Time.	Observer's Remarks.
2. C. A. Y.	$3^h\ 00^m\ 13^s\!\cdot\!5$	Notch disappeared promptly. No traces lingering on limb.
3. C. G. R.	3 00 02	Last moment when notch was *certainly* seen.
4. C. I. Y.	3 00 14	Disappearance of notch.
5. C. F. B.	3 00 08	Planet broke contact with sun.
	00 22	Momentary renewal of disturbance of limb at point of rupture.
6. M. McN.	3 00 00	Last trace of notch.
7. W. L., Jr.	3 00 00	Last trace of notch.
8. W. F. M.	3 00 06	Lost sight of planet.
9. H. C.	2 59 50	Last seen of Venus.
10. H. L. B.	3 00 29	Unsteady. Venus disappearing and reappearing.
	At South	*Hadley.*
11. R. F. W.	$2^h\ 58^m\ 30^s$	Very unsteady. Time probably much too early.

At Princeton, at the time of this last contact, there was comparatively little cloud, but the air was very unsteady and the sun's limb was serrated. Nothing was seen of the planet's atmosphere between third and fourth contacts except that for a few moments, about $2^h\ 45^m$, W. M. T., the writer saw fine spurs of light running out a little way from the sun's limb on each side of the planet's disc.

VI. MICROMETRIC MEASURES.

During the Transit I made two sets of measures of the planet's diameter; one with a double-image micrometer, the other with a filar micrometer. The screw-values of the two instruments were obtained a few days after the Transit (when the temperature was about the same as on Dec. 6th) by means of several hundred transits of small sun-spots across wires, observed with the chronograph.

The double-image measures consisted of 4 sets, each of 10 readings. They give:

For the north and south diameter (pos. ang. 0° and 180°), $62''\!\cdot\!33$
" east and west " (" 90° and 270°), $61''\!\cdot\!89$

Mean .... $62''\!\cdot\!11$

Reduced to unity distance, $16''\!\cdot\!43$.

The filar micrometer measures consisted of 8 sets of 10 readings each, at position angles differing by 45°. They give:

Pos. angle,	0° and 180°	64″·29
"	40° and 225°	64″·43
"	90° and 270°	63″·93
"	135° and 315°	64″·57
Mean		64″·23

Reduced to distance unity, 16″·99.

The difference of 2″·1 between the double-image and filar micrometer is more than would have been anticipated, and I am not now able to explain its magnitude. I shall reëxamine the micrometer constants, but suspect the difficulty lies in the observer.

The double-image micrometer gave a power of about 600, and the images were always very pale and sometimes almost invisible; they were at no time sharply defined, clouds being very troublesome nearly all the time. The power used on the filar micrometer was about 250. During its use the seeing was much better than it had been during the double-image observations; it was never really very bad, and much of the time it was very good, so that the details of the solar surface came out finely.

VII. Spectroscopic Observations.

Spectroscopic observations were made both by Mr. McNeill and myself. Immediately after second contact I uncovered the whole aperture of the telescope, and attached the Clark spectroscope with a diffraction grating of about 17,000 lines to the inch. The slit was made tangent to the limb of the planet at the point most remote from the sun's center. I first tried the spectrum of the first order, examining specially B, *a*, and the interval between C and D. The clouds at the time were pretty thick and the results were negative, except that now and then I thought D_1 was a little intensified. A little later the sun came out brilliantly, and I at once turned to the third order spectrum. B and *a* still remained unaffected, nor could I make out certainly anything due to the planet's atmosphere between C and D. *But the vapor lines just below D_1 and between D_1 and D_2 were unmistakably intensified close to the planet's limb.* The same thing could also now be seen in the spectra of the first and second orders. I prepared to replace the grating by a prism giving low dispersion in order to search for diffuse bands of absorption, but the clouds thickened again, and the obscuration continued so long that it became necessary to exchange the spectroscope for the double-image micrometer.

Mr. McNeill's observations were made with the 9½-inch equatorial, carrying the Grubb spectroscope. This has a dispersive power of from 2 to 10 prisms, variable at pleasure. During the observations 4 prisms were used for the most part (i. e. 2 prisms transmitting the light twice). Mr. McNeill saw the vapor lines between and near the D's, and thought he noticed a slight strengthening of both A and B. He did not observe any change in a, but a fine line just above C was intensified, and the line at 759·2 of Kirchoff's scale ($\lambda=6392$) appeared to be distinctly affected.

At South Hadley Mr. West attempted observations with a grating spectroscope upon the 8-inch equatorial, but did not get any results; the image of the planet was too unsteady.

The effects of the planet's atmosphere upon the spectrum were certainly much less marked than I had expected; but I think there can be little doubt as to lines of aqueous vapor near D.

VIII. Photographic Work.

During the Transit a series of 191 photographs were taken by Professor Brackett and his assistants, Professor Libbey and Mr. Magie. The apparatus was a horizontal photoheliograph of the same general plan and dimensions as those used by our Government parties. The plates and chemicals were furnished by the Transit of Venus Commission, which receives the pictures for measurement and discussion.

The wind and clouds interfered somewhat with the operations. About 40 of the photographs are strictly first-class, and some 30 are worthless; the remainder are of all grades of excellence, from very good to very poor, but are probably all measurable.

Miscellaneous.

The atmosphere of the planet was seen by all the observers at Princeton between the first and second contacts. No one, however, saw the peculiar enlargement of the ring of light noticed by Professor Langley at Allegheny, though I did particularly observe that the structure of the ring appeared to be radiate and bristling, with scintillant knots here and there. No satellite was detected. No ring was seen on the sun's disc surrounding the planet except such as would necessarily result from the imperfect color-correction of the object-glass. No spots or markings were seen upon the planet's disc, which at ingress appeared slightly but distinctly darker than the background on which it was projected.

March, 1883.

ART. XXXIII.—*Notes on the Occurrence of certain Minerals in Amelia County, Virginia;* by WM. F. FONTAINE.

IN Amelia County, Virginia, near the county-seat, a considerable amount of excavation has been made during the past few years for the purpose of obtaining mica. This work has brought to light a number of interesting, and some very rare minerals. I have several times visited this locality and noted the occurrence of the minerals found there. It is my purpose in this paper to make known some of the facts observed.

All the minerals noticed in this paper occur in so-called veins of gigantic granite, situated in the immediate vicinity of Amelia Court House. These granite veins have the same general features as those that in other regions afford marketable mica. They are not fissure veins, but are ruptured portions of the country rock, into which the components of the granite have been introduced, most probably, by solution in hot water. The vein matter is chiefly a mixture of quartz and feldspar which serves as a gangue in which the masses and crystals of mica occur in a porphyritic manner. Sometimes, however, all of these minerals occur forming a confused web or entangled mass.

This material forms bosses, or irregular and interrupted veins in a thinly-bedded, highly micaceous gneiss that alternates with or graduates into mica-schist. The rocks are thoroughly metamorphosed, and their constituents occur in well individualized and rather coarse particles. These rocks form a belt that has the character attributed to the typical Montalban formation. The belt now in question may be traced for a long distance to the northeast and southwest of Amelia, and is usually marked by the occurrence of the veins of gigantic granite. It lies just west of the granitoid gneiss that is so extensively quarried near Richmond.

The vein-like deposits of granitic matter seem to occur in a pretty well defined band, but are not continuous over long distances. They occur more commonly "en echelon," sometimes overlapping each other. Some of them, over limited distances at least, seem at one time to have been open crevices. Some have remained undisturbed since their first filling, but others have evidently been reopened or disturbed more than once, and have received new materials.

The feldspar, mica and quartz, the essential minerals of these deposits, appear to have pretty constantly consolidated and crystallized in the same order of succession. The mica was the first to crystallize; the feldspar came next; and the quartz was the last to assume the solid form.

It is quite evident that some of these deposits near Amelia C. H. have in prehistoric times been worked to some extent. On opening the deposit near the village that has afforded the largest amount of mica, I am informed it was found that the outcrop had been removed for the depth of about ten feet. Refuse mica, stones and clay were then thrown back into the excavation. At a spot about two miles distant from this, I saw myself indications that the outcrop of a mica deposit had been disturbed. For the depth of ten or twelve feet, the earth had either been thrown in, or washed in upon the deposit which had been removed to that depth. On the top of the undisturbed deposit, and under about twelve feet of foreign earth, small bits of charcoal could be found.

Plates of mica that have an accurate rhombic shape, may be found here. They appear to have been trimmed into that form.

It is quite possible that these slight excavations were made by Indians, perhaps from curiosity. About two miles from this spot is a considerable outcrop of potstone that has been quite extensively worked by Indians, for the manufacture of pots and other utensils. This locality has been explored by the Smithsonian Institution, and has yielded quite a number of relics.

The most extensive excavations for mica have been made on the land of Mr. Rutherford, about one mile north of the Court House. Here two pits were dug, one on a hill of small altitude, and the other about one hundred yards distant, on a small stream. Both openings seem to be on the same deposit, but, as they show considerable differences in the occurrence of the minerals, it will be necessary to distinguish them. The one on the hill may be called No. 1, and that on the stream No. 2. Neither exceeds eighty feet in depth. From these two pits all the rare minerals have been taken.

The quartz found here shows no points worthy of mention. The mica is mostly muscovite. It is clear, and without color. Occasionally small particles of a beautiful rose-red mica are found. More commonly, but still rarely, a pale, yellowish green mica occurs that looks as if it were colored by uranium. The muscovite is sometimes bent, showing movements in the vein.

Feldspar.—The feldspar presents some points worthy of note. Much the larger part of the feldspar found in both pits is orthoclase. That found in pit No. 1 is mostly, when fresh, light-greenish in color. The feldspar of pit No. 2 is mainly yellowish-white. The orthoclase in both of these pits is nearly always found in crystalline masses. At an opening made some two miles to the northeast of these pits, which may be called pit No. 3, a nest of very large orthoclase crystals was

found. One of them, which is not the largest, is in the form of a rectangular prism, formed of the faces O and $i\bar{\imath}$ much prolonged. It has at one end several prismatic faces, while the other end is broken, since it formed the place of attachment. This crystal is 50 centimeters long, while the cross-section shows in one direction the dimension of 22½ centimeters, and in the other 20 centimeters.

Pit No. 1 shows but little feldspar other than orthoclase, but a considerable amount of albite occurs in pit No. 2. The larger part of this albite occurs in forms that I have seen assumed sometimes by stalagmitic deposits when they fill up vertical crevices in limestone, and there is little doubt but that this albite results from a secondary deposition of material, that made its way into an open crevice in the mass of material first deposited. This albite, for a depth of over twenty feet, formed a portion of the deposit composed of a closely-interlocked network of plates of a beautiful bluish-white material. Often angular cavities and cells were left from the incomplete filling of the space. At the bottom of this cellular mass, an open cavity was found, four or five feet long and high, and one or two feet wide. In the bluish white albite, and in the walls of this cavity, some minerals were found that do not occur elsewhere. Numerous crystals of smoky quartz lined the walls of this cavity along with pure white crystals of albite, some as transparent as glass. The quartz has often mingled with it a greenish powder that is evidently a decomposition product. The minerals found here were evidently deposited after the formation of the mass of granitic material, forming the bulk of the vein.

A small amount of labradorite occurs dispersed in a porphyritic manner in the masses of orthoclase. It is usually of a smoke-gray color, and sometimes shows a slight change of color on turning the specimens.

A considerable amount of amazon stone is found, but most of it occurs in pit No. 2. It ranges in color from bluish-green to verdigris green. The mode of occurrence of this feldspar strongly suggests the idea that the color comes from solutions infiltrating into the deposit from the surface, and making their way through the crevices of the vein. The green color most commonly is deepest in the portions of a mass of spar next to a fissure, or line of dislocation, and fades gradually until it is entirely lost in the mass of the material. Hence, often, hand specimens will be only partly colored.

Beryl.—The beryls, which occur of large size and quite commonly, are found almost wholly in pit No. 2. Some of them are surpassed in size only by those of New Hampshire. They are found sometimes three or four feet in length, and as much

as eighteen inches in diameter. The most common colors are pale bluish green and dingy yellow. The latter color is so much like that of some of the feldspar, that it is sometimes difficult to distinguish the two minerals. The beryls seem to have crystallized at the same time with the feldspar and after the mica. Some masses are formed of the yellowish feldspar and beryl so closely consolidated, that they seem to shade off into each other. In the quartz, however, the beryl crystals are easily separated, and leave sharp imprints of their crystalline form. I have seen one beryl crystal that shows crystals of mica projecting from its prismatic faces, and in several places, where the mica had fallen out, a distinct imprint of its crystalline form was left in the beryl.

All the beryls found in the two pits are opaque, but in pockets of quartz found in the vicinity, small transparent crystals, half a centimeter thick and under occur, that have a good luster, but not a deep color.

Fluorite.—This mineral occurs not rarely, and mostly in pit No. 2. I have never seen it in crystals. It is found always in crystalline masses that shatter easily into small fragments. Only a few particles show good cleavage. The mineral is usually found occupying the irregular angular spaces left between the particles of the feldspar, mica and quartz. Two colors predominate, a pale purple and a pale green. Some fragments show a very deep, dark green color. The fluorite is remarkable for the great beauty and brilliancy of the phosphorescent light that it gives out at quite low temperatures. The light is rich bluish green in color. After decrepitation it no longer gives out light.

Columbite.—This mineral occurs quite commonly, and it is more abundant in pit No. 2 than in pit No. 1. It is found quite often in crystals, some of them being of large size. They are, however, very easily broken, and can almost never be gotten entire from the feldspar, which is always the mineral that contains them. Some crystalline masses weighing six to eight pounds exist. I have one mass which is an aggregation of crystals that shows the following dimensions: length 12 centimeters, width 11½ centimeters and thickness 11 centimeters. It appears to be a mass formed by the aggregation of crystals that have a flat shape from the predominance of the $i\bar{i}$ faces. All of the masses of columbite found here are friable and easily break up into angular fragments.

A variety of columbite occurs here rather rarely, that differs from the normal mineral both in chemical and physical characters.* This, as Professor Dunnington has shown, contains con-

* A somewhat similar mineral had been previously found at Branchville, Conn., and analyzed by Comstock.

siderably more manganese than iron, and has the ratio of columbic to tantalic acid 1 : 1. In mass it has a dark chestnut-brown to dark reddish brown color. Some particles tend to assume a fibrous structure, and then the color is somewhat lighter. In very thin splinters the color is a rich hyacinth-red. The normal columbite, so far as known, is the only kind that occurs in the upper part of the vein. The variety now in question is found only in pit No. 2, and becomes more abundant with increasing depth. Mr. Search, a gentleman connected with the mining operations and a zealous collector of the rare minerals found there, informs me that just before the pit was abandoned he found in the walls, a few feet above the bottom, a mass of this variety of columbite that weighed about five pounds. Portions of this mass in my possession show the tendency to assume a fibrous structure. These fragments are much like some kinds of rutile. For the analysis of this variety of columbite, the reader may consult the account of it given by Professor Dunnington, in the Am. Chem. Jour., vol. iv, p. 138. The columbite crystallized before the feldspar, and leaves in it well-defined imprints of its form.

Garnet.—In pit No. 2, garnet of the variety spessartite is quite common, forming one of the primitive minerals of the vein. This garnet occurs in poorly formed crystals that are penetrated with a multitude of fissures, so that the mineral readily shatters to pieces. This form has a hyacinth-red to brownish red color, and is imbedded in the ordinary feldspar of the vein stuff. This mention is made of it to distinguish this kind of garnet from another of the same variety, viz: spessartite, that shows quite a different mode of occurrence, and which is specially noteworthy on account of its intimate connection with helvite. This second form of spessartite occurs in the form of a loosely aggregated mass, composed of granules and angular particles, but never in crystals. The granular mass is intimately mixed with helvite, the latter filling the interstices between the particles of spessartite. The compound is inserted in the cavities left between the interlacing crystals of albite that were formed on the walls of the large cavity discovered in pit No. 2. Both this spessartite and the helvite are clearly minerals deposited in the vein after the filling of the greater portion of it by the more abundant materials composing the vein stuff. The order of deposition seems to have been as follows. First, the beautifully clear albite crystals were formed on the walls of the cavity, producing an open network with large interstices. In some of these the spessartite was loosely deposited, and lastly, in some of the cavities between the particles of spessartite helvite was laid down. The helvite is very rare, and does not occur associated with all of the spessartite.

The spessartite thus associated with helvite has the following characters. Fusibility = 3 ; hardness = 6·5 ; sp. gr. = 4·20. Composition:

SiO_2	36·34
Al_2O_3	12·63
FeO	4·57
MnO	44·20
CaO	1·49
MgO	·47
Water	a faint trace.
	99·70

The color is pale pink to flesh-red. Some fragments are brownish purple. The mineral looks more like some rhodonite than like garnet. It will be noted that the manganese is unusually high, and the iron and alumina unusually low.

The above analysis, with the determination of the specific gravity and hardness, was made by Mr. C. M. Bradbury in the laboratory of the University of Virginia.

Orthite.—Orthite is found in great abundance at the locality, pit No. 3, that furnishes the very large feldspar crystals mentioned above. Here some of the thin-bladed crystals may be seen more than fifteen inches long. It is also not rare in pit No. 2, but here the crystals rarely show lengths exceeding six to eight inches. In all cases both ends are broken off. Those of the greatest length do not exceed in thickness 4^{mm} and in width 2 to $2\frac{1}{2}^{cm}$. In shape they are much like an ordinary ivory paper cutter.

The mineral, so far as I have observed, always occurs imbedded in feldspar or a mixture of feldspar and quartz. It usually has a decomposition crust of varying thickness, and sometimes the whole crystal is altered. The crust has an ash-gray color and is without luster. It is sharply distinct from the fresh interior. The internal sound portion has a velvet-black color and a high pitchy luster.

This mineral has been analyzed, independently, by Professors Kœnig and Dunnington. For the analysis of Professor Kœnig, see Proc. Acad. Nat. Sci. Philadelphia, 1882, p. 103; for that of Professor Dunnington, the Am. Chem. Jour., vol. iv, p. 138, may be consulted.

Microlite.—This is the most interesting of the minerals found in the mica mines of Amelia County. It occurs only at pits Nos. 1 and 2. I have carefully looked for it at the other openings made for mica in the vicinity without finding it. The largest masses were found in pit No. 1, some twenty feet below the surface. These masses occurred in the northern end

of the pit, and occupied the interstices left in the tangled mass of quartz, feldspar and mica that forms the main portion of the vein-stuff. The microlite, whether in crystalline masses, or in distinct crystals, was one of the original minerals of the vein. It crystallized after the mica, for some of the specimens have the faces distinctly marked by the overlapping edges of plates of mica, but before the feldspar, for the crystals are usually imbedded in feldspar, and leave sharp impressions in it. The larger masses of the mineral are aggregates of crystals, and show often on the component parts several crystal faces. The single crystals, which are most numerous in pit No. 2, occur imbedded mostly in feldspar, but they are sometimes found in quartz, or in a web of quartz and mica. It is noteworthy that minute crystals are very rare. I have seen a few from 3 to 5^{mm} in diameter, imbedded in quartz. The well-formed single crystals have usually the diameter of 1 to $1\frac{1}{2}^{cm}$. Microlite occurs also in the walls of the cavity that was found in pit No. 2, along with the albite crystals.

At the first discovery of the microlite of Amelia, the existence of monazite was overlooked, because the specimens that had then been found were much like microlite. The slight difference in appearance was accounted for by the assumption that the microlite had been decomposed or altered to some extent. Hence, in the publication of his article on microlite, in the Am. Chem. Jour., III, ii, 130, Professor Dunnington gave as the weight of one mass of microlite eight pounds. This specimen was really monazite, as subsequent analysis showed. This mistake, however, would not lead to erroneous conclusions concerning the size that some of the microlite specimens attain. I have a fragment of microlite that, no doubt, was originally not inferior in weight to the above-mentioned specimen of monazite. This fragment of microlite when found had been broken off from a much larger mass, as is shown by the surface of fresh fracture. The portion in my possession weighs four pounds fifteen ounces. The whole mass must have weighed over eight pounds. This specimen is an interesting one. It is composed of a number of distorted octahedral crystals of large size, united in an irregular manner. On one side the surface is marked with imprints caused by the overlapping plates of mica, under the edges of which the microlite was deposited. The color of the microlite varies a good deal. The colors range from pale yellowish gray, through brownish yellow to dark hair-brown. The brownish yellow color is that of the best characterized fresh material. This color, with the high resinous luster, and the broad, shallow conchoidal fracture, often causes the mineral to look like some of the gums. The single crystals show constantly the same forms.

They are octahedrons, modified by small faces of *O*, *I*, and *m-m*. All the faces of the same form are not always present, and when present, they are usually not equally developed. The largest single crystal that I have seen is slightly distorted. The longest axis has the dimension of $4\frac{1}{2}^{cm}$. In the direction of the other axes, it measures about 3^{mm} less. This crystal in forming has caught up, and partially imbedded some columbite. This would indicate the prior formation of the columbite, but this is not true of all the columbite, for it sometimes imbeds portions of microlite. This difference results from the fact that microlite was deposited at different times, some being found as stated, with the albite, helvite, etc., in the walls of the cavity previously mentioned.

The microlite seems to be a very durable substance. As illustrating this, the fact may be mentioned that a fragment of feldspar was found containing a number of crystals of microlite. The feldspar was almost wholly changed to kaolin, while the microlite retained its luster and hardness. Professor Dunnington, in the article above mentioned, has given the analysis and description of this mineral.

Monazite.—Monazite has been found nowhere except at pits 1 and 2. It occurs much as the microlite does, and is often so much like it that it requires close inspection to distinguish the two minerals. It exists usually in larger masses than the microlite, and what is peculiar, never in single or small crystals. The masses, however, are aggregations of distorted crystals, and often show on the constituent parts, well-formed crystal faces. Another noteworthy fact may be mentioned. Cleavage is either wholly absent, or present only in traces. The fracture is very uneven and rough. This is the best means to distinguish it from microlite. The large masses are often formed by the aggregation of imperfect flattened crystals, the plane of junction being the *ii* faces. Some of these masses have much the shape of some of the aggregations of columbite.

Two colors are common in this mineral. One is yellowish brown, and the other dark grayish brown. In the mineral with the latter color, numerous fine particles of silvery-white mica are often found. Besides the above, an orange color is sometimes seen. The different colors often occur together, the same specimen showing them in different parts. This mineral does not seem to have formed one of the later deposited ones, as it is not found in the cavity associated with albite, etc. The monazite is decidedly more prone to alteration than the microlite. It is sometimes found with an earthy texture, having lost its luster and become more gray in color.

Professor G. A. Kœnig first recognized monazite among the Amelia minerals. For his analysis, see Proc. Acad. Nat. Sci.

Philad., June 24, 1882. Professor Dunnington has analyzed this monazite also. For his results, see Am. Chem. Jour., vol. iv, p. 138. The most noteworthy feature of this analysis is the considerable amount of thorina found.*

Helvite.—This mineral occurs very rarely, and is found only in pit No. 2. It seems to occur only in the walls of the cavity in this pit, and is deposited in the interstices of the light pink spessartite mentioned above, which is itself found in the openings between the albite crystals that formed on the walls of the open space. The helvite seems to have been the last mineral to be deposited in the vein, and its constant association with such a highly manganiferous garnet, is an interesting feature. It seems to have been deposited in the form of crystalline granular particles, that rarely show crystal faces or forms. A good deal of it is now in a pulverulent condition that may result from partial alteration. This mineral has been carefully examined in the laboratory of the University of Virginia by Mr. B. E. Sloan, pure material being taken. I extract the results of this examination from the "Notes of Work of Students," etc., etc., published originally in the London Chemical News.

"Color, wax- to lemon-yellow; streak, very pale lemon-yellow; luster, vitreous; translucent; hardness = 6; sp. gr. = 3·25. Fusible before the blowpipe flame with intumescence. Decomposed by hydrochloric acid with the formation of gelatinous silicic acid, and the liberation of sulphuretted hydrogen. Analysis gave—

SiO_2,	31·42
BeO,	10·97
MnO,	40·56
FeO,	2·99
Al_2O_3,	0·36
Mn,	8·59
S,	4·90=99·88

Another interesting mineral was found in pit No. 2, but unfortunately in so very small amounts that a complete quantitative analysis of it could not be made without using all of the material. It shows no crystal faces, but the structure is much like that of the normal columbite that occurs at this mine. The color is pinchbeck-brown, with a tinge of purple, causing the mineral to look like bornite. The purple may be a color from partial alteration, as it is quite intense on some particles. The streak is very pale yellowish brown to flesh-red. Hardness=6·5. Sp. gr.=6·82. In composition it is a tantalate,

* Mr. S. L. Penfield, in his analyses published in this Journal in October, 1882 (xxiv, 250), concludes that the thorina present is from mixture with thorite.—Eds.

mainly of manganese, with a large amount of lime, and a small amount of iron. The examination was made by Mr. Dunnington who ascertained with certainty the absence of columbic acid. Possibly this mineral may be allied to Nordenskjöld's mangantantalite.

The following minerals also occur, but very rarely:

Galena.—Small fragments of galena are found sometimes in pit No. 2. The largest particles seen by me have the dimensions of from 3 to 5^{cm}. This galena is said to be argentiferous. It has not been tested here.

Stibnite.—Mr. G. W. Fiss, of Philadelphia, who has taken great interest in collecting the minerals of the Amelia mica mines, informs me that he has found stibnite among them in one piece. I have seen no pure stibnite, but have in my possession some fragments of mixed galena and stibnite.

Pyrochlore.—Mr. Fiss informs me that he has found a piece of pyrochlore also at these mines. I have seen none.

Apatite and black tourmaline occur very rarely in pits No. 1 and 2. A brick-red mineral also is found in very minute particles in pit No. 2. It has the hardness of fluorite, and gave Mr. W. H. Seamon reactions for cerium, indicating the presence of fluocerite. V Ca = Ce

One or two additional minerals from this locality remain to be more fully examined, and they will probably prove to be of interest.

University of Virginia, Jan. 27, 1883.

ART. XXXIV.—*On the Surface Limit or Thickness of the Continental Glacier in New Jersey and adjacent States;* by J. C. SMOCK, New Brunswick, N. J.

[Read at the Montreal meeting of the American Association for the Advancement of Science.]

A PAPER under the above title was presented by the author to the Association at the meeting at Saratoga Springs, in 1879. The discussion which followed its reading at that time suggested further explorations in the field and a general review of the whole question. The results of field work in 1880, 1881 and this season, with the revised data of previous years, have been incorporated in this paper.

It is proper here to put on record a reference to the work done in New Jersey in tracing the terminal moraine across that State. The existence of such a moraine and of a southern limit to the glacial drift in New Jersey was suggested to the author, in 1876, by Professor George H. Cook, State Geologist. Dur-

ing the summer of that year it was traced across the State from Perth Amboy to the Delaware River, near Belvidere. The work was the subject of a paper read at the Wilkesbarre meeting of the American Institute of Mining Engineers in May, 1877, by Professor Cook.* A short notice of it appeared in the annual report of the State Geologist for 1877.† In the next annual report of the State Geological Survey the moraine was more fully described and was represented upon a State map accompanying that report. The course across Staten Island and Long Island was given,—as the continuation of the New Jersey moraine. Its course in Pennsylvania was traced and described by Professor Frederick Prime, Jr., of the Geological Survey of that State.‡ The general subject of a continental moraine from Long Island westward, to Iowa and Minnesota, has been discussed by Professor T. C. Chamberlin, State Geologist of Wisconsin, in a memoir entitled, "On the Extent and Significance of the Wisconsin Kettle Moraine," published by the Wisconsin Academy of Sciences. Professor Chamberlin has correlated the eastern and western terminal moraines in an article in this Journal for August, 1882. The eastern continuation of the moraine, on Long Island, was described by Warren Upham, lately of the New Hampshire Geological Survey, in this Journal in 1879.§ The results of the labors of Professor H. C. Lewis of the Pennsylvania Geological Survey, in mapping out the southern limit of the ice sheet in Pennsylvania, have not yet appeared.

While engaged in tracing the course of the moraine in New Jersey, the questions of the thickness of the ice of the glacier and the rise of its upper slope, were suggested by the varying heights of its mounds and the absence of drift on the higher peaks which stood in its course. The terminal moraine represents materials pushed forward under the foot of the glacier, and also earth and stone carried on its surface and dropped as it melted and retreated northward. The heights of these accumulated heaps may in places have been equal to the greatest thickness of the ice front, although in general the moraine would fall short of that of the glacier. As we see it, this terminal moraine varies in height from point to point. The inequalities are no doubt largely owing to irregularities in the original deposition. But the denudation, which has been in progress ever since the ice began to melt, has probably done more in giving to it its present contours. It is possible to get a minimum estimate for the thickness of the ice from some of the

* Transactions Am. Inst. of Mining Engineers, vol. vi, pp. 467–470, Easton, Pa., 1879.

† Ann. Rep. of the State Geologist for 1877, pp. 10–11, Trenton, 1877.

‡ Proceedings of the Am. Philosophical Society, vol. xviii, p. 85.

§ This Journal, III, xviii, pp. 81–92, and 197–209.

elevations in the line of the moraine. Poplar Hill, near Woodbridge, New Jersey, is 240 feet above tide; Drift Hills near Clifton Station on Staten Island, 190 feet; Prospect Hill, Brooklyn, 194 feet; Harbor Hill, near Roslyn, Long Island, 384 feet; many others on Long Island are between 150 and 370 feet.* It is safe to conclude from these heights that the thickness of the ice sheet in this southern loop of the Hudson Valley was at least 200 to 400 feet. Other localities farther to the west and northwest furnish data of like nature. At Feltville in Union County, a bowlder limit is recognized at an elevation of 400 feet above tide. On Second Mountain, west of Feltville, there are scattered bowlders up to 440 feet. The general level of the sandstone plain on the east side of the First Mountain range is 150 feet, giving a difference of 250 to 290 feet as a measure of the ice at this point. Again, at Long Hill, near Chatham in Morris County, the glacial drift is wrapped about the north foot of the ridge and pushed forward to the south on each side. The upper bowlder limit here is 390 feet high. The Passaic River, flowing in the bottom of the red sandstone valley on the east of this hill, is 177 feet above tide or 200 feet below the bowlder line. Another locality, exhibiting like phases in the drift, is on Snake Hill, near Denville, also in Morris County. On the northern point of this sharp and rocky ridge of gneiss the moraine is traceable at an elevation of 670 feet, but scattered bowlders as high as 770 feet indicate the latter elevation as the ice limit. The crest line of this range is 910 feet high. On each side the drift sweeps southward, lying against the hill. The general level of the plain north of the hill is 570 feet, but the valley bottom or rock floor is lower and consequently the glacier must have been more than 200 feet thick as it encountered Snake Hill. It was not, however, thick enough to reach the crest. The glacial phenomena on the next hill to the west of Snake Hill are very similar to what has been mentioned above. Three ranges, approximately parallel, stood thus in the way of the glacier, and were partly covered by it. But their summits overtopped the ice and escaped glaciation. Dover in Morris County is at the foot of the moraine whose height above tide-level is at this place 640 feet. The rapid rise in the drift hills to 960 feet northward indicates that the ice sheet thickened rapidly in that direction. West of Dover the long valley, which may be designated as the Berkshire–Succasunna, exhibits some striking drift phenomena. Separate masses of glacial drift are here found lying about the northern ends of Potsdam sandstone ridges, while the intervening valley is filled with exceedingly

* Elias Lewis, Jr., in a note to Professor Dana in this Journal, III, vol. xiii, p. 235.

coarse bowlder drift, modified and made from the destruction of the once continuous moraine. These sandstone ridges also were but partially covered by the glacier as it here neared its most southern extension. The elevation of the drift upon them varies from 700 to 900 feet. The highest points on the Schooleys Mountain table-land are the summits of the moraine hills, which are 1,200 to 1,300 feet above tide. And this is the maximum elevation along the line of the moraine in New Jersey. From this height as compared with that of the Musconetcong Valley on the west, there is a descent of 700 feet, which becomes a measure of the ice as it lay in that valley. Westward the course of the moraine is more southwest. There was a loop or tongue projecting southward in the valley of the Delaware. At Tonnsbury in Warren County there is a bowlder limit on Mt. Mohepinoki at 950 feet, which is at least 450 feet above the bottom of the Pequest Valley at the village. The upper surface would seem to have been lower here than on Schooleys Mountain. In the valley of the Delaware the drift hills range from 490 to 560 feet in height and are 250 to 320 feet higher than the river. The erosion of the river bed may have been considerable since the close of the glacial period, and this difference may be more than equal to the thickness of the glacier which filled the valley at this place.

From these notes on the moraine elevations in New Jersey, the inference seems to be that the ice foot was highest in the Highlands and was there thicker than elsewhere in the limits of the State. The glacier pushed southward in the red sandstone plain and attained a latitude of 40° 30′, at the mouth of the Raritan River. The most southerly point at which we have any record of it, in the Delaware Valley, was near Belvidere,—in latitude 40° 50′. Both of these loops appear to have been thinner near their southern edges than the mass on the Highlands. The differences in elevation in these valleys and on the Highlands may give us the rate of increase in thickness from north to south. For example, at Dover the moraine is 22 miles north of the latitude of Perth Amboy, and the elevation at Dover is 640 feet. If at Amboy the ice was but little above or near the level of tide-water, the rate of descent would be nearly 30 feet per mile. Other examples could be cited, but they have been printed. (See Annual Report of the State Geologist of New Jersey for 1877, pp. 12-13.) The much greater rise per mile in the Delaware Valley shows that the rate was not uniform. Nor is it at all probable that measurements elsewhere will correspond in rate with the examples referred to above. Inequalities in the surface over which the ice moved, differences in the rate of accumulation of the snows and ice as well as in that of its wasting away and its retreat,

made uniformity in the front of the glacier for even 100 miles of its course impossible.

Recognizing the southern limit of the glacier and finding these evidences of its thickness along the terminal moraine, search was begun for points to the north which might have been high enough to have escaped glaciation. Finding such points we should have data for ascertaining the rate of rise in the upper slope of the ice. Existing glaciers, as those of Greenland, which are continental in extent, and the great ice cap of the Antarctic pole, give some hints of what we should expect to find among the records left us by our continental glacier. Professor Nordenskjöld states "that in Greenland, when at the extreme point which he reached, thirty geographical miles from the coast, he attained an elevation of 2200 feet, and that the inland ice *constantly continued to rise* toward the interior, so that the horizon toward the east, north and south, was terminated by an ice-border almost as smooth as that of the ocean."*

Dr. Hayes and his party penetrated inward to the distance of about seventy miles. At that distance the altitude was 5000 feet, but the ascent had diminished from 6° to 2° on the upper slope of the icy mass. But the ice has not covered some of the highest peaks of Greenland and they stand out as islands in the ice and are known as "ice-bare islands," or "*nunataks.*" One of the most noted of them explored by Lieutenant Jensen of the R. D. navy is about fifty miles from the west coast, north of Fredericshaab and rises 3000 feet above the ice, to a height of 5000 feet above sea level.† Here then we find a measure of the ice covering Greenland.‡

The observations of geologists upon glacial phenomena in Scotland, England and Switzerland indicate an upper limit to the ice of the glaciers, which formerly covered these countries. James Geikie, of H. M. Geological Survey, says in a paper on the "Glacial Phenomena of the Outer Hebrides:"§ "The actual thickness of the ice sheet it is now possible to measure with some approach to exactness. We have seen that the only points in the Outer Hebrides, which have escaped glaciation, are those that exceed a height of 1600 feet. Taking this, therefore, as the thickness of the ice that overflowed the lowest ground of the Long Island and 3000 feet as the probable upper

* "Climate and Time." James Croll, p. 379.

† Robert Brown in Enc. Brit., 9th ed. (N. Y., 1880), vol. xi, p. 167.

‡ Professor James D. Dana, in this Journal, August, 1882, vol. xxiv, pp. 100, 101, refers to the height of the ice in Greenland in the Glacial Era, as indicated by glacial scratches which were observed by Mr. A. Kornerup of Jensen's Expedition. These scratches were found at 940, 1100 and 1260 meters elevation. But none were found on the upper part of peaks. 1520 meters (4987 feet) high.

§ Quarterly Journal of the Geological Society for November, 1878, pp. 860–861.

limits of the ice sheet in Western Ross and Sutherland, we readily arrive at the depth of the ice sheet that filled up the Minch. . . . . . Measuring from the Cliseam, in North Harris, to the mountains of Torridon, we have a distance of fifty-six miles, so that the inclination of the surface of the *Mer de Glace* was very little, the fall not being more than 1400 feet, or about 1 in 211. But slight as that incline was, it was probably twice as great as that of the *Mer de Glace* that filled up the German Ocean." This inclination, in other terms, is twenty-five feet per mile.

Professor A. C. Ramsay, Director of the Geological Survey of Great Britain, in his "Old Glaciers of Switzerland and North Wales," says: "All through Britain and Ireland this drift rises well up on the flanks of the mountains, and in Caernarvonshire and North Wales, generally, the surface, is over large areas more or less covered by true GLACIAL DRIFT, rising from underneath the sea to a height of about 2300 feet on some of the mountains."

In Switzerland, according to the Swiss geologists, a mighty *Mer de Glace* moved down from the Alps and carried huge blocks across the lower grounds to the Juras. "This vast sheet of ice not less than 3000 feet in thickness, stretched continuously outward from the Rhone Valley and abutted upon the Jura, the higher ridges of which rose above its level."*

These phenomena of the glacial drift in Europe, which have afforded data for measuring the thickness and the slope of the upper surface of the ice sheets of the glacial epoch, have suggested the examination of like phenomena in our territory, with a view to the discovery of facts of glaciation enabling us to get a measure of the continental glacier which covered the northern portion of our American continent.

A careful exploration of that part of New Jersey, which is north of the terminal moraine, has thus far failed to discover any peaks or crests which have escaped glaciation, or which show no marks of a glacier. An examination of the highest mountains of the New York Highlands and also of the lofty Schunemunk Mountains has discovered glacial markings on all of these high points.

The Shawangunk Mountain also is glaciated to its crest. The lofty table land of the Pokono Mountains in Pennsylvania near the line of the Delaware, Lackawanna & Western railroad, whose summit is 1970 feet above tide, was found covered by glacial drift. A single ridge, however, of this same range and same geological formation, known as Pokono Knob, eight miles west-northwest of Stroudsburg, Pa., appears to

* "The Great Ice Age," James Geikie, p. 371.

have stood above the ice. Bowlders and drift earth cover its flanks and constitute much of the surface material to within a vertical distance of 50 to 100 feet of the top. On the crest of the ridge the ledges of grayish white conglomerate are much broken up and lie in blocks. None of them show any glacial markings. Nor are there any erratics or drift earth on this crest. The absence of characteristic glacial phenomena leads to the conclusion that the ice did not attain this height. The mountain is 2025 feet high and the glacial limit may, therefore, be put at about 2000 feet. The whole country to the eastward and southeast, including the Kittatinny Mountain—at the Delaware Water Gap was covered by the glacier, and on it glacial markings are common.

But the testimony of Professor I. C. White, of the Pennsylvania Geological Survey, who has examined Pokono Knob is still more positive. He says: "During the past year (1881) I made the survey of Monroe County and ascended Pocono Knob, I was unable to find any evidences of glaciation, either of *scratches* or *drift* on its summit, hence I concluded that the deep valley of Pocono Creek to the east had lowered the upper limit of the ice, since on the Pocono plateau in Coolbaugh township, glacial striæ were observed at an elevation of 2150 feet (A. T.)"*

Professor White's survey of Susquehanna and Wayne Counties discovered several peaks on the border line of these counties which also escaped glaciation. Elk Mountain, Ararat and Sugar Loaf of the Moosic Highlands appear to have stood out, above the ice. Professor White says: "2200 feet (A. T.) is the greatest elevation at which I have observed direct evidence of glaciation, either in the shape of morainic débris or striated rock surfaces. All higher summits which I have examined are destitute of *drift deposits*."† North Knob, the highest of these peaks, is 2700 feet high; South Knob rises to 2575 feet; while Sugar Loaf and Ararat are 2450 and 2600 feet, respectively. As remarked by Professor White: "These summits, which probably existed as elevated hills in pre-glacial times, were left as islands in the ice moving southward, and escaped the universal abrasion to which every other portion of the township was subjected; for no appearance of drift or glacial scratches can be found on their sides or summits." These driftless peaks are about sixty-five miles north of Belvidere, the most southern point reached by the glacier in the Delaware Valley. And the rate of rise in the upper slope

* Letter to the author of this paper from Professor White, Morgantown, W. Va., April 3d, 1882.

† "The Geology of Susquehanna County and Wayne County," by I. C. White, Harrisburg, 1881, pp. 25 and 158–159.

may have been near thirty-five feet per mile, although from the fact of the glaciation on the Pocono Highlands considerably farther south, we should infer that the rise was by no means uniform, but was much faster near the glacier front.

Sam's Point, the highest part of the Shawangunk range and 2341 feet high (according to Professor Guyot), which is in the same latitude as the Moosic Highlands, is glaciated to the top. Walnut Hill or Liberty Hill, in Sullivan County, New York, also exhibits glacial abrasion and drift to within 200 feet of its summit, or at an altitude of 2000 feet.

During a short visit to the Catskill Mountain region, in the summer of 1877, the great height of the western and southwestern peaks of that mountain group suggested the possibility of finding there the upper limit of the ice, and the ascent of Hunter Mountain was made that season. Visits have been made to this region each year since, and many of the more prominent, and all the higher peaks, have been ascended and their slopes and summits examined for glacial phenomena. The excellent and valuable map of Professor Guyot, published in 1879,* has served as a constant guide and furnished the data for elevations, although an independent series of barometric measurements has been taken and found to agree closely with the figures of Guyot's map. In this group of mountains there are at least fifty peaks which exceed 3000 feet, and three which are over 4000 feet high. The general trend of the mountain ranges is northwest and southeast, but the higher peaks stand on northeast and southwest lines. The amount of erosion in the Catskills has been very great, since the strata are nearly everywhere horizontal, or inclined but a few degrees from the horizon. The main valleys appear to have been eroded prior to the glacial epoch, and the existing features were largely determined by the long-continued wear of pre-glacial waters, so that the ice sheet did little beyond filling partly some of the valleys and abrading the more prominent of the lower ridges. The valleys are, essentially, of erosive origin, obscured, however, now by glacial débris in many places. In some of them, as that of the Batavia Kill in Windham, the Stony Clove and Woodland Valley, there are very plainly marked moraines, indicating the existence and retreat of local glaciers. The larger valleys of the Schoharie Kill, the east branch of the Delaware, and the Esopus Creek, also have their moraines, though not so well defined. Subsequent to the retreat of the great mass of the continental glacier these valleys were no doubt occupied by detached glaciers. The torrents flowing from them evidently modified much of the older drift and deposited it in a stratified form in these valley bottoms as we now

* This Journal, III, vol. xix, pp. 429–451.

see it. In this way the moraines were partly destroyed. Ascending these valleys to their head, the upper limits of the thick drift masses are reached, beyond which, on the steeper mountain slope, the explorer finds the evidences of glaciation in *roches moutonnées* and scattered bowlders only. The heights of these moraine limits vary somewhat in the different valleys. Thus, at the head of the Batavia Kill Valley and near Black Dome, it is about 2700 feet; west of the Catskill Mountain House, and near Tannersville, it is at least 2000 feet; on the northern slope of Hunter Mountain it is 2200 feet; in the Stony Clove Notch it is about 2000 feet; in the notch west of Slide Mountain, and at the headwaters of the Neversink, it is 2650 feet; near Summit Station, on the U. & D. railroad line, it is 2200 feet; near Margaretville, 2000 feet; on the southeast slope of Mt. Pisgah, northwest of Margaretville, it is 2800 feet; and near Stamford, at the head of the west branch of the Delaware, it is 2000 feet. Of course, it will be understood that these thicker glacial deposits are, to a great extent, determined by the configuration of the rocky floors or valleys in which they were deposited, and their elevation is, therefore, approximately that of these valleys. But, inasmuch as the slopes rise much higher, affording surface for deposition at greater altitudes, it is probable that the average of these elevations, from 2000 to 2800 feet, was the upper limit of the *moraine profonde*, or till. The scratched ledges, sub-angular bowlders and gravel, and the glacial earth, which lie on the higher slopes, indicate that the ice encountered the more elevated mountain sides and left its marks upon them. And this sparse drift was, doubtless, from the upper surface of the glacier. In order to ascertain the thickness of the ice the heights of these higher markings and deposits must be found. And here it should be stated that the examination of the higher slopes and the summits is rendered difficult by the accumulations of the forest growth upon them and by the wear of subaërial agencies, as frost and water, during the ages since the close of the glacial epoch. The action of frost may have obliterated all the more exposed markings. The rock also is not the best fitted to retain glacial marks. The results of our repeated visits to this region point to a general absence of all the more characteristic features of glaciation above an average elevation of 3000 feet above tide level. Above this horizon the forms are apparently the result of aqueous and atmospheric agencies. The proofs of such an upper limit to the glacier may be given in the following order:

1. Above it the outcropping rocks are more abrupt and precipitous, even on the north slopes, and there are no marks of any abrading or polishing agent. No *roches moutonnées* have been discovered on these higher peaks and slopes.

2. The outcrops and the surface on these summits and higher slopes are made up either of angular, sharp-edged rocks in place, or the slightly worn blocks and rock fragments and earth of the same nature as the ledges, and apparently derived from them. Much of this material seems to have been broken off by the action of frost. Had a glacier moved over these mountain tops it would have removed this débris, or rounded the stones and more prominent ledges.

3. There is a general absence of drift earth and of stones foreign to the rocks *in situ*. There do not appear to be any erratics nor mixed earths. A glacier would have left some foreign materials to mark its course.

4. The phenomena on these higher peaks correspond with what are so common and so characteristic of the country lying south of the terminal moraine. No glacialist can avoid noting this resemblance. If the latter is unglaciated, the former must be also.

The only explanation left is that there was a limit to the ice sheet, above which it did not go. It was not thick enough to cover all of these peaks.

The following table gives the elevations of glacial drift or markings. The heights were determined by barometric observations, viz:

On Black Dome	2940	feet.
North Mountain	2500	"
Indian Head, or Round Top	2800	"
Overlook Mountain (striæ)	3000	"
High Peak (old Round Top)	3250	"
Hunter Mountain	2800	"
Wittemberg Mountain	2900	"
Slide Mountain	3080	"
Mt. Pisgah (west of Margaretville)	2930	"
Ontiora	3300	"
Utsyanthia	3200	"

These heights are the upper limits to which glacial phenomena could be traced with certainty. No doubt more careful explorations, by uncovering the rock, would discover some markings at greater heights. We have given what has appeared to be the general horizon. Local variations, even within narrow limits, would be expected. It should also be borne in mind that the existence of the great glacier, filling all the lower valleys, and overtopping many of the peaks of the Catskills necessitated a degree of cold and other conditions which favored the accumulations of snows on these higher peaks, analogous to the snow coverings of all mountain peaks above the snow line. And in some cases they may have amounted

to incipient glaciers, whose melting did much to mix materials and round off ledges and bowlders or loose blocks. The rounded ledges of some localities above the horizon given above, and the slightly rounded rock fragments found near them, may have had their origin in some such way.

The direction of the striæ and the grooves are omitted, as not pertinent to the question. Suffice it to say here that they indicate a general southwest movement.

That such an upper limit of the glacier was probable has been indicated repeatedly by Professor James D. Dana in his Manual of Geology and in articles in this Journal. In one of these latter, on the Mohawk Valley Glacier, he says: "On the Catskills the glacier scratches reach to a height of 2235 feet—the elevation at the Mountain House—and this implies the existence of ice and snow to a height of at least 2600 feet; and if the snow had this height over the whole southern plateau it would have almost completely buried it, with the exception of the higher Catskill summits."* This language seems almost prophetic. But the ice reached higher than Professor Dana at that time supposed, though still not high enough to bury the higher summits.

The only mountains in New England which approach the height of the Catskills, and are in the same latitude, are Mt. Everett in Massachusetts and Greylock, in the same State, but little farther to the north. Of the first-named, Professor Dana says that its glaciated summit "affords evidence that the ice which covered New England in the Glacial Period overtopped this mountain, and had an elevation in that region not much under 3000 feet. Similar facts in the White Mountains place the height there at not less than 5800 feet. Calculating the slope of the upper surface of the glacier over New England from these data, it follows that the height above the region of New Haven, in southern Connecticut, may have exceeded 2000 feet, and could hardly have been less than 1500."†

Mt. Everett is due east from Overlook Mountain (of the Catskill group) and is eighty-eight miles north of the terminal moraine on Long Island. From the Slide and Wittemberg Mountains to the same moraine—at Perth Amboy—the distance is 108 miles. These figures give a descent to the glacier surface of less than thirty feet to the mile, and less than one-half of a degree. But this rate corresponds closely with that obtained by Professor Geikie for the Scottish Glacier, viz: 1 in 211.

From what is known of the Greenland glacier and the great Antarctic ice-cap we should infer that the inclination of the

* This Journal, II, vol. xxxv, p. 249.
† This Journal, III, vol. x, p. 168.

continental ice-sheet of the glacial epoch was not uniform The rise was probably steep near the margin. And the high glaciated points near the line of the terminal moraine indicate that such was the fact. Thus, near Feltville and Summit, the drift-covered Springfield Mountain, which is about a mile north of the line, is nearly 600 feet high.

The high drift-hills near Mount Hope (960 feet) show a great thickness near the margin. The height of Schooleys Mountain drift has been referred to, and the thickness of the ice in the Musconetcong Valley. Northward the angle of the slope diminished and the glacier surface approximated to a great level plain. The distance between the high, southwestern peaks of the Catskills, and Pocono Knob in Pennsylvania, is sixty miles. The difference in the elevation of the glacier could not have exceeded 1000 feet. In that direction the slope was less than on a meridian line from the Catskills, southward. Going north, the highest peaks of the Adirondacks are 150 miles distant from the Catskills, and the Green Mountains are quite as far away in the north-northeast. Assuming that the rise was fifteen feet per mile only, it would have been enough to have overtopped Mt. Marcy and Mt. Mansfield, and, of course, all the lower peaks in these groups of mountains. The explorations of Professor Charles H. Hitchcock show that even the White Mountains were submerged by the ice of the glacier. So that we have no outstanding peaks farther north. The great glacier appears to have covered the whole of New England and northern New York, and to have filled the Hudson Valley to a depth of at least 3000 feet, as far south as the Catskills, burying the Berkshire Hills, the Shawangunk Mountain range, and the Highlands of southern New York, in its icy folds. Above it stood the higher peaks of the Catskills and the summits of the Moosic Highlands as isolated landmarks—or islands in the great *Mer de Glace*.

ART. XXXV.—*Contributions to the Geological Chemistry of Yellowstone National Park.*

Geyser Waters and Deposits.

THE following include all the specimens analyzed which are not distinctly siliceous.

1. *Mammoth Hot Springs, Old 9th Terrace Spring.*

	Grams to Imp. gallon.
Sodium sulphate	34·44
Sodium chloride	18·90
Calcium carbonate	17·92
Magnesium carbonate	8·68
Silica	3·36
	83·30

2. *Deposit from Mammoth Hot Springs.*—This was in white masses evidently incrustations. The structure was distinctly radiated. It was soluble in hydrochloric acid with effervescence, leaving only a trace of residue.

Calcium carbonate	96·80
Magnesium carbonate	1·36
Alumina and iron oxide	0·45
Silica	0·25
Water	0·50
	99·36

3. *Cleopatra Spring.*

	Grams to Imp. gallon.
Sodium sulphate	35·504
Sodium chloride	13·496
Calcium sulphate	13·587
Calcium carbonate	24·850
Magnesium carbonate	7·455
Silica	3·500
	98·392

Rocks of the Park; by WILLIAM BEAM.

3. *Rock from Yellowstone Cañon near Falls.*—Consists of white, opaque fragments, rough to the touch. Fracture conchoidal, texture porous. Hardness, 3·5; sp. gr., 2·36; fusibility, 5·5. Gives a colorless bead with microcosmic salt and borax; moistened with cobalt nitrate and heated, it turns bright blue. Hydrochloric acid dissolves 14·6 per cent of the powdered mineral. Analyses gave:

SiO_2	64·60
Al_2O_3 and Fe_2O_3	25·65
MgO, CaO	traces
K_2O	·76
Na_2O	·43
H_2O	8·70
	100·14

The rock has the appearance and qualities of a very compact or baked clay; it adheres strongly to the tongue; when breathed upon has a distinct pipe-clay odor, and the powder becomes plastic with water. Not being familiar with this region, I am unable to give a full explanation of the character of this rock; but I incline to the view that it is a clay metamorphosed by proximity to a dyke or lava stream. The specimens examined may have been taken at some distance from the source of heat, as it seems difficult to suppose that a clay would retain its plasticity after having been heated to the degree which immediate contact with the melted rock would cause.

4. *Trachyte from Junction Valley.*—The pieces were greenish-blue, interspersed with white and dark spots and small particles of free silica. Fracture uneven. Hardness, 4·5; sp. gr., 2·84; fusibility, 5·5. Gives reaction with borax for iron. Heated with cobalt nitrate, the whole parts become blue and the rest brown. Composition:

SiO_2	69·90
Al_2O_3	17·58
Fe_2O_3	2·41
CaO, MgO	traces
K_2O	4·16
Na_2O	2·41
H_2O by ign.	3·65
	100·11

ART. XXXVI.—*Notes on American Earthquakes:* No. 12. By Professor C. G. ROCKWOOD, Jr., Ph.D., Princeton, N. J.

THIS article embodies such information as the author has obtained in regard to the earthquakes which occurred on the American continent and adjacent islands during the year 1882, with notice of some earlier ones not before reported here.

Items which depend on single sources of information usually have their source indicated; and if regarded as doubtful, are printed in smaller type.

For assistance in collecting information the author is again indebted to J. M. Batchelder, Esq., of Boston; to Professor F. E. Nipher, of the Missouri Weather Service; to Dr. J. W. Dawson, of Montreal; to Charles Carpmael, of the Meteorological Service of Toronto; and especially to Mr. Edwin Rockstroh, of the Ynstituto Nacional, at Guatemala, to whose kindness are due the unusually full reports from that region.

The Monthly Weather Review of the U. S. Signal Service has also furnished much valuable information.

1879.

June 8.—10.51 A. M. An earthquake occurred at San José de Costa Rica.

June 19.—3.00 A. M. A slight shock at Guatemala.

Sept. 21.—11.13 A. M. A weak shock at San José de Costa Rica.

Oct. 11.—12.45 A. M. A slight shock at Guatemala.

Nov. 18.—10.40 A. M. A weak shock at San José de Costa Rica.

Dec. 29.—7.43 P. M. A somewhat strong earthquake at San José de Costa Rica.

1880.

Jan. 11.—8.42 P. M. A slight shock at Guatemala.

The following were all at San José de Costa Rica.

Jan. 7 and 26. Weak shocks.

Mar. 3.—9.50 A. M. A weak shock.

Mar. 17.—10.32 A. M. A strong shock.

May 15.—8.31 P. M. A light shock.

May 22.—6.17 P. M. A light shock.

May 25.—2.58 A. M. A strong shock of seven or eight seconds' duration.

July 13.—7.30 P. M. A weak shock.

Dec. 30.—10.04 P. M. An earthquake of three seconds' duration.

1881.

Jan. 23.—5.30 A. M. A moderate shock at Guatemala; reported also (5.55 A. M.) at San José de Costa Rica.

Mar. 3. During the night of the 2d and 3d several slight shocks were felt at San Marcos, a town northwest from Guatemala.

Mar. 7.—7.52 A. M. A slight shock, lasting three seconds, reported from Dos Caminos, Mexico.

Mar. 15.—1.50 P. M. A moderate shock lasting four seconds at the same place.

Mar. 29. A moderate shock (N. to S.), reported from Oaxaca (12.50 P. M.), and Tlacolula (12.55 P. M.).

Mar. 30. Slight shocks reported at Villa Juarez Ixtlan (12.55 A. M., N. to S., 5 sec.), and at San Carlos Yautepec (1.30 P. M., E. to W., 4 to 6 seconds.).

The last four items are by E. R., from a Mexican paper.

April 6. A heavy shock reported from San Salvador, Central America.

April 16 to 22. More than fifteen moderate shocks, all vertical, reported from San Salvador during these six days.

April 27.—10.20 A. M. and 11.30 A. M., moderate shocks at Guatemala.

April 28. At 9 P. M. a violent shock with vertical movement, lasting more than fifty seconds, did some damage at Managua, in western Nicaragua, and was followed by other shocks at 10.00, 11.00 and 11.30 P. M. The first shock was also reported as very heavy at San Juan del Sur and Chinandega, and was felt at various points between these places.

May 13.—5.30 P. M. A slight shock, S. to N., duration three seconds, at San Carlos Yautepec, Mexico.

May 27.—12.15 P. M. A slight shock, duration three seconds, at Oaxaca, Villa Juarez Ixtlan, and San Carlos Yautepec (S. to N.), Mexico, and also at San Cristobal las Casas (1 P. M., E. to W.).

May 29.—1.40 P. M. A slight shock at Guatemala.

Aug. 13.—12.30 P. M. A strong earthquake at San Marcos, Guatemala; felt also slightly at the capital city.

Sept. 25.—4.20 P. M. An earthquake of about two seconds' duration at San Cristobal las Casas, (Chiapas) Mexico.

Oct. 3.—9.30 P. M. A slight shock at Acaponeta, Mexico.

Oct. 17. At 12.50 A. M. a shock of two seconds' duration at Dos Caminos, Mexico. At 1.55 P. M. a strong shock, duration three seconds, at Chilpancingo.

——— Also at Mexcala, hour not given, a strong shock of two seconds' duration, probably coincident with that last mentioned.

Oct. 19.—4.20 P. M. A strong shock at Tehuantepec, Mexico, duration six seconds.

Oct. 20.—2.58 P. M. Another shock at same place, duration four seconds; reported also at Juchitan, with direction E. to W.

Oct. 21.—At 8.05 P. M. a shock, E. to W., duration three seconds at Tlacolula, Mexico.

——— At 9.22 P. M. and 11.30 P. M. shocks of six and two seconds, at Tehuantepec, with subterranean rumbling.

——— A shock was reported the same day from Oaxaca, hour not stated, direction E. to W., duration six seconds; very likely coincident with one of those mentioned above.

Oct. 22 to 27. Shocks were noted at Tehuantepec as follows: 22d, 4.10 A. M. (6 seconds); 8.15 P. M. (3 seconds); 9.20 P. M. (3 seconds); 11.30 P. M. (4 seconds). 23d, 1.00 A. M. (11 seconds and rumbling); 8.53 A. M. (rumbling); 9.30 A. M., 10.00 A. M., 11.38 A. M., 3.37 P. M., 7.05 P. M., 8.43 P. M., 10.00 P.M. (all 3 or 4 seconds). 27th, 10.03 A. M. (N. to S., 3 seconds).

All the above items, in 1879–81, are from Mr. E. Rockstroh, of Guatemala.

1882.

Jan. 8.—5.10 P. M. A shock of ten seconds' duration at Cape Lookout, N. C. *U. S. Weath. Rev.*

Jan. 20.—10.02 P. M. A slight shock at Guatemala. E. R.

Jan. 26. Two severe shocks in the evening at Centreville, Cal.

Feb. 3.—2.40 A. M. A sharp shock, direction apparently S. to N., at San Gorgonio, California. *U. S. Weath. Rev.*

Feb. 12.—1.30 A. M. A shock at Pagosa Springs, Lake City, and Capitol City in southwestern Colorado.

Feb. 26.—6.25 P. M. A shock, lasting three or four seconds, at Murray Bay, Quebec.

Mar. 2. At 2.48 A. M. a strong shock, lasting twenty-four seconds, was felt at Guatemala, and the neighboring places, doing some damage in Antigua. At 5.58 A. M. a less heavy shock followed, lasting seventeen seconds. The direction of these two shocks at Guatemala was S.W. to N.E. The same night five moderate shocks were reported from Salamá, a town sixty miles north from Guatemala. E. R.

Mar. 3.—7.48 A. M. A strong earthquake, from N.E. to S.W., in San José de Costa Rica; duration, forty-seven seconds. It was felt also in Puntarenas, Alajuela, Heredia and Cartago, and generally from the dividing ridge between the oceans to the Pacific coast. Light shocks followed in Puntarenas, at 11.30 P. M. of 3d and 4.30 A. M. of 4th.

The first accounts of this earthquake were greatly exaggerated, reporting a loss of several thousand lives. The real damage appears to have been very slight.

Mar. 11.—4 P. M. A slight shock, N. to S., at San Diego, California; reported also from Poway, California, at 3.30 P. M.

Mar. 16.—1.15 A. M. A strong shock at San José de Costa Rica; duration, two seconds. E. R.

Mar. 16. A shock in the morning in the City of Mexico. *N. Y. Times.*

Mar. 16.—1.46 P. M. A light shock in San Francisco, California. *U. S. Weath. Rev.*

Mar. 21.—1.30 A. M. A weak, and at 2.42 A. M. a strong, shock at San José de Costa Rica. E. R.

March. At Salinas City, California, light shocks twice during the month. *U. S. Weath. Rev.*

April 2. At Newmarket, Va., several shocks reported in the evening.

April 2. Two shocks in the morning at Amsterdam, N. Y. J. M. B.

April 11.—11 P. M. A slight shock in New Orleans, La. *N. Y. Times.*

April 13.—6.30 A. M. A sharp shock, N. to S., lasting about four seconds, in San Francisco, Cal. *U. S. Weath. Rev.*

April 17. "A few minutes past two o'clock" a sharp shock at Hopkinton, N. H. J. M. B.

April 30. At 10.48 P. M. the vicinity of Portland, Oregon, was shaken by two earthquake shocks, a few seconds apart, the first light, the second more severe, with a low rumbling; vibration in a general west-east direction. Another light shock followed at 12.25 A. M. of May 1. The heavier shock was reported as far north as Olympia, W. T., and Victoria, B. A.

May 1. An earthquake at East Greenwich, R. I. J. M. B.

May 8. About 4 A. M. a slight shock at Concord, N. H. *Concord Monitor.*

May 11.—8 P. M. A slight shock at Pagosa Springs, Col. *U. S. Weath. Rev.*

May 21.—9.37 P. M. A moderate earthquake in Guatemala. E. R.

June 8 to 10. At 11.52 P. M. of 8th, at 9.20 P. M. and 9.28 P. M. of 9th, and at 10.37 P. M. of 10th, moderate earthquakes in Guatemala. E. R.

June 27.—5.22 A. M. Two severe shocks at San Francisco and vicinity, each about ten seconds' duration, with four seconds between. They were felt along the coast from Petaluma to Hollister, and as far inland as Stockton.

July 15.—7.45 P. M. A sharp shock at San Francisco, Cal., felt slightly at Point San José.

July 19.—2.35 P. M. A very severe shock in the City of Mexico, lasting two and a half minutes. It was said to be the most severe since 1864.

July 20.—4 A. M. A shock, duration fifteen seconds, at Cairo, Ill.

July 22.—11.08 A. M. A very light shock at San Francisco, Cal. *U. S. Weath. Rev.*

July 28. A single shock, hour not stated, at Ironton, Mo.

July 31. About noon a light shock at Cape Mendocino, Cal. *U. S. Weath. Rev.*

Aug. 1.—6 P. M. A light earthquake at Point des Monts, at the mouth of the St. Lawrence River. *Canadian Meteorol. Serv.*

Aug. 8. Light shocks, S.E. to N.W., at Oakland, Cal. *U. S. Weath. Rev.*

Aug. 9.—8.45 P. M. A light shock at San Francisco, Cal. *U. S. Weath. Rev.*

Aug. 15.—10.30 A. M. A strong earthquake at Point des Monts, Quebec. *Canadian Meteorol. Serv.*

Aug. 24.—3.56 P. M. A moderate earthquake in Tecpan, Patzizia and Quezaltenango, Guatemala. E. R.

Aug. During the month two severe earthquakes and several minor shocks occurred in Caraccas, Venezuela. *H. D. Warner, in Atlantic Monthly.*

Aug. At Salinas, Cal., shocks were felt twice during the month. *U. S. Weath. Rev.*

Sept. 6. An earthquake in Aux Cayes, Hayti. *Troy (N. Y.), Daily Times.*

Sept. 7. About 3.20 A. M. (variously given from 3.15 to 3.24), the isthmus of Panama was shaken by a very severe earthquake lasting about sixty seconds. This violent shock had been preceded by rumblings, and was followed by another shock after half an hour, and by other lighter shocks during that and the succeeding days, especially at 1 P. M. and 11.30 P. M. of 7th, and about 5 A. M. of the 9th. The violent shock affected a very wide extent of country. It was felt at Panama, Aspinwall and generally throughout the isthmus and adjacent islands; at Rivas and Greytown in Nicaragua; at Guayaquil, in Ecuador; at Buenaventura and Cartagina, in Colombia; at Maracaibo and Caraccas in Venezuela; that is, along the whole northwestern coast of South America. At Panama the Cathedral and other public buildings were partly overthrown and fifty or sixty houses were injured. The damage was estimated at $250,000. Two lives were lost by falling walls. The railroad between Aspinwall and Panama was injured in many places by the sinking of the road-bed and the breaking of culverts, and the telegraph cable from Aspinwall to Jamaica was broken by the shocks about fifty miles from the isthmus. At Caraccas, where the most violent shock occurred at 2.20 A. M., the loss amounted to eight persons killed, twenty-six wounded, sixty-two buildings totally destroyed and sixty-seven others badly cracked.

Sept. 13. In the evening a slight shock reported in Caledonia, Livingston County, N. Y.

Sept. 19.—4.17 P. M. A moderate earthquake in Guatemala. E. R.

Sept. 20. At noon a light earthquake at Point des Monts, Quebec. *Canadian Meteorol. Serv.*

Sept. 27. At 4.20 A. M. (St. Louis, Mo., time), a somewhat severe earthquake was felt throughout southern Illinois. Its influence extended west and east, from Mexico, Mo., to Washington, Ind., and Henderson, Ky.; and north and south from Springfield, Ill., to Pinckneyville, Ill., being reported from numerous places within these limits. The area affected would therefore be an ellipse, measuring 250 miles east and west by 160 miles north and south. From many places round about this area and in its borders came the report that *no* shock was felt, so that its boundary is pretty well defined. The time stated above is based upon several closely accordant and trustworthy observations in and near St. Louis. The reports from other persons varied all the way from 2.15 A. M. to 5.05 A. M. The reports of direction were equally various, but on the whole point to a general east-west motion which is also indicated by the form of the district affected. In very many places more than one shock was reported, the number being variously given from two to twelve. In almost all places subterranean rumbling was heard, but a few places, as Whitehall, Ill., and Louisiana, Mo., distinctly reported that *no* sound was heard. The motion was sufficient to crack chimneys, overthrow small objects, as toilet bottles, and set pictures vibrating. This summary is based on reports from over fifty different places, for many of which I am especially indebted to Professor F. E. Nipher.

Sept. 30.—10.57 A. M. A sharp shock at Campo, Cal., lasting two seconds; direction S.E. to N.W. *U. S. Weath. Rev.*

Oct. 8. At 2.00 A. M. a heavy shock, lasting several seconds, at San Diego, Cal.; felt generally in the surrounding country.

Oct. 8.—5.00 A. M. A sharp shock at Antigua, W. I. *N. Y. Times.*

Oct. 9. News of this date from Cape Haytien, W. I., says: "Three slight shocks of earthquake were felt here during the past week."

Oct. 10.—4.15 A. M. A slight shock at Montreal; felt also at Lachine, St. Hiliare, Huntingdon and other points near.

Oct. 11.—11.15 P. M. A slight shock at Panama.

Oct. 12. "An earthquake shock is reported to have been felt in the southern part of Humboldt Co., Nev." *U. S. Weath. Rev.*

Oct. 13.—4 P. M. Two sharp shocks at St. Thomas, W. I.

Oct. 14–15. About midnight southern Illinois again felt several shocks of earthquake similar to that of Sept. 27th but feebler. The district affected was from St. Louis and St. Charles, Mo., east and northeast to Springfield and Decatur, Ill. It was also reported at Indianapolis, Ind. There appear to have been at least three distinct shocks, the first at 11.49 P. M., St. Louis time (reported at Collinsville, 11.50½ P. M.); another between 12 and 1 A. M., and a third between

4 and 5 A. M. At Manchester, Scott Co., Ill., the times were given as 12.33 A. M. and 4.35 A. M. Most observers reported only two of the three shocks, some the first two and others the last two. Centralia, Ill., was the only place where all three were reported.

Oct. 15. At 12.30 P. M. a slight shock reported at Murphy, N. C. *U. S. Weath. Rev.*

(Should *p. m.* be *a. m.*, and this be a part of the earthquake in Illinois already noted?)

Oct. 20.—1.40 A. M. A slight shock at Lima, Peru. *N. Y. Times.*

Oct. 20.—2.15 A. M. A severe shock at San Francisco, Cal., felt lightly at Point San José.

Oct. 20. At 7.30 (A. M.?), a slight shock at San Salvador, Cent. Amer. *N. Y. Times.*

Oct. 22.—At 12.10 A. M., Indianapolis time, a slight shock at Greenville, Bond Co., Ill.

Oct. 22. About 4.15 P. M. an earthquake was felt in northern Texas, western Arkansas and eastern Kansas, and presumably in the intervening portions of the Indian Territory. The region affected extended from Greenville and Paris, Tex., and Little Rock, Ark., northwesterly to Wichita and Leavenworth, Kan., a distance of some 300 miles. The shock was reported from numerous places within these boundaries, and also, as a light shock, from Warrenton, Mo., which is farther eastward. The most definite report of time was from Wichita, Kan., which gave 4.19 P. M., Jefferson City, Mo., time. In many places two or three pulsations were noticed, having a duration of about thirty seconds in all. Reports of direction are too various to be classified. No damage was done other than overturning movable articles and knocking bricks from chimney-tops.

Oct. 23. About 7 P. M. a slight shock reported at Newberne, N. C. *U. S. Weath. Rev.*

Oct. 31.—6.45 P. M. A sharp shock at San Francisco, Cal., felt also at Sonoma, Napa, Petaluma and San Rafael; vibration east and west.

Nov. 7. About 6.30 P. M. an extensive earthquake was felt in Colorado, Wyoming and Utah. It was reported from Salt Lake City and all along the Union Pacific R. R. eastward to Laramie City and Cheyenne, Wyoming Ter.; from Georgetown and Louisville, Col.; from Denver, where the clocks were stopped at 6.25 P. M., and from Salina, Kansas. At some places three shocks were noticed. The direction was generally east and west, and the intensity sufficient to set chandeliers vibrating.

Nov. 14. In the morning an earthquake at Panama, felt on both sides of the isthmus.

Nov. 14. A light shock felt at St. Louis, Mo., 9.14 P. M. (9.16½ P. M., by B. D. Kribben); at St. Charles, 9.21 P. M., and at Collinsville, Ill., 9.17½ P. M.

Nov. 27.—6.30 P. M. A severe shock occurred at Welland, Allanburg, Port Colborne and other places along the Welland Canal between Lake Erie and Lake Ontario.

Nov. 28.—5.15 P. M. A sharp shock at San Salvador, Cent. Amer.

Nov. 30. A second lighter shock at daylight at the same place. *N. Y. Tribune.*

Dec. 11. Two slight shocks at Santiago de Cuba followed by a more severe one on the morning of the 12th. *N. Y. Times.*

Dec. 19. About 5.20 P. M. a shock occurred in the southeastern part of New Hampshire. It was felt at Dover (5.15 P. M.), Contoocook (5.20 P. M.), Concord (5.24 P. M.), New Market (5.25 P. M.), and other neighboring places. It lasted several seconds and was accompanied by a rumbling noise.

Dec. 19. Two slight shocks at Panama.

Dec. 19.—11.45 P. M. Two light shocks, east to west, at Visalia, Cal. *U. S. Weath. Rev.*

Dec. 31. About 10.05 P. M. a decided shock with rumbling noise was felt in Halifax, N. S. and other places along the railroad to Truro. It was also reported from Eastport (9.55 P. M.), Rockland (10.00 P. M.) and Bangor (9.30 P. M.), in Maine.

The above record for 1882 includes seventy-two items, of which thirteen are in small type. They may be classified geographically as follows:

Canada,	6		
New England,	5,	3	doubtful.
Atlantic States,	6,	4	"
Mississippi Valley,	11,	2	"
Pacific Coast,	19,	3	"
Mexico and Central America,	18		
Venezuela,	1		
West Indies,	5,	1	"
Peru,	1		
	72	13	

The following may be selected as the more important of the earthquakes noticed above:

March 2, Guatemala; March 3, Costa Rica; April 30, Oregon; June 27, California; Sept. 7, Central America; Sept. 27, Illinois; Oct. 14, Illinois; Oct. 22, Arkansas, Kansas, etc.; Nov. 7, Colorado and Wyoming.

Thirty-six items are added to the record of previous years. They all refer to the Central American region, and are distributed as follows: 1879, six; 1880, nine; 1881, twenty-one.

Princeton, N. J., March 12, 1883.

ART. XXXVII.—*A Four Years' Record of Earthquakes in Japan, studied in their Relation to the Weather and Seasons;* by THOS. H. STREETS, M.D., U. S. Navy.

"FROM time immemorial it has been asserted by the natives of the countries which are most frequently ravaged by earthquakes, that these commotions bear some intimate relation to the movements of the atmosphere, and very generally coincide with certain meteorological conditions, such as rainy seasons, numerous storms, warm and damp winds."—(Reclus, Earth.) Humboldt, likewise, seemed to have been impressed with the importance of this relation. He says, "but if no meteorological phenomena indicate the coming earthquake, either on the morning of the shock or a few days previously, the influence of certain periods of the year (the vernal and autumnal equinoxes), the commencement of the rainy season in the tropics, after long drought, cannot be overlooked even though the genetic connection of meteorological processes, with those going on in the interior of our globe, is still enveloped in obscurity."—(Cosmos.)

Japan is preëminently a country of earthquakes, as the list given abundantly testifies. It was compiled from the weather statistics kept at the United States Naval Hospital at Yokohama, Japan, which is a station for taking international meteorological observations. The list includes every shock, that could be appreciated without the aid of a seismometer, that occurred in a period of four years, beginning with 1878; and, counting only those that were separated by a lapse of several hours; there were in this period 124 distinct shocks. There is no questioning the accuracy of the accompanying observations, which were carefully recorded every three hours. The height of the barometer above the sea-level is 115 feet.

In the first place I think we may conclude that the barometer gives no indication of the approach of an earthquake; but the charts would indicate that they are associated with a comparatively high state of atmospheric pressure. Between the highest and lowest barometer with which they were accompanied, there is a variation of little more than one inch, from 30·44 to 29·33; and within these limits we have them occurring under the most variable conditions of the barometer, when it was rising and when it was falling, as well as when it was steady.

At first sight it would appear as if the shocks were associated with atmospheric commotions. About 75 per cent of them preceded, or accompanied, rainy or threatening weather, or heralded clearing weather. To one unacquainted with the

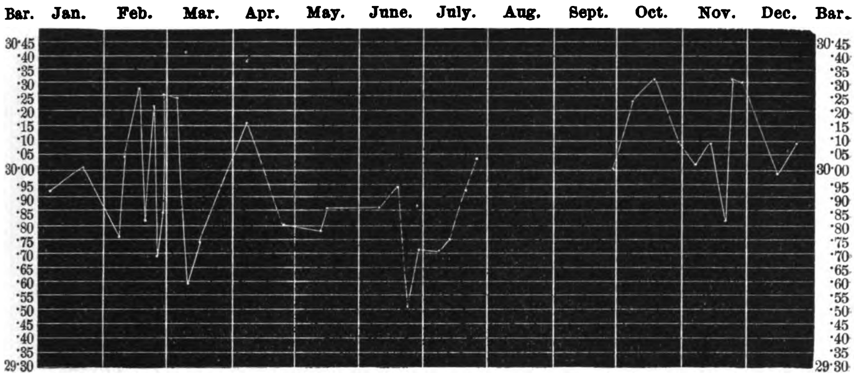
Date.	Number.	Time.	Barometer.	Sky.	Remarks.
1878					
Jan. 22	2 shocks	3.19 and 3.35 P. M.	29·91 rising	clear	
24	smart shock	3.30 P. M.	30·00 rising	clear	1·23 in. of rain on the 26th.
Feb. 5	slight shock	3.27 P M.	29·75 falling	cloudy	Light rain and sleet.
11	shock	7.26 P. M.	30·04 steady	clearing	After 5¼ in. of snow-fall.
17	3 shocks	A. M.	30·27 falling	cloudy	Light rain next day.
19	slight shock	1.16 P. M.	29·82 rising	cloudy	Midnight strong winds.
23	2 shocks	A. M.	30·21	cloudy	
24	shock	9.45 A. M.	29·69 rising	rain	
25	smart shock	10.24 P. M.	29·84 rising	clearing	
27	light shock	0.26 A. M.	30.25 rising	clear	28th, A. M., rainfall of 1·26 in.
Mar. 5	sharp shock	3.00 P. M.	30.24		Fol'w'd by rainfall of 1·17 in.
6	light shock	2.06 P. M.	29·59 falling	cloudy	Barometer rising at 3.30 P. M.
7	slight shock	10.25 P. M.	29·74 rising	clearing	Followed by 9 d. of cl'r sky.
Apr. 9	slight shock	2.45 P. M.	30·16 falling	rain	Followed by 8 days of rain [and cloudy weather.
28	slight shock	4.05 P. M.	29·80 rising	rain	
May 10	slight shock	9.10 P. M.	29·78 rising	clearing	
11	light shock	7.14 A. M.	29·86 rising	cloudy	Light rain next day.
Jun. 11	smart shock	0.15 P. M.	29·86 falling	clear	
17	smart shock	5.20 A. M.	29·94 rising	clearing	After a rainfall of 1·47 in.
22	shock	12.00 M.	29.52	clearing	Light rain in the morning.
28	smart shock	6.34 P. M.	29·72 rising	rain	Rainfall of 2·54 in.
July 5	light shock	4.39 A. M.	29·72 falling	rain	Sky clearing during day.
10	shock	0.46 A. M.	29·75 falling	cloudy	
15	smart shock	3.45 P. M.	29·93 rising	clearing	11 rainy days since the 1st.
20	light shock	8.46 P. M.	30.03 rise	clear	Strong S. W. wind during day.
Aug.					No earthquakes during this month: 19 rainy days.
Sep. 30	light shock	5.32 A. M.	30·00 falling	cloudy	18 rainy days during month.
Oct. 8	slight shock	10.48 P. M.	30·24 rising	clearing	After 2 days light rain.
9	smart shock	1.20 P. M.	falling		Followed by light rain. [rain.
17	shock	10.25 A. M.	30·31 rising		Began to fall next d.: 19th,
31	light shock	10.15 P. M.	30·10 falling	clearing	After 2½ hours of rain.
Nov. 5	light shock	0.57 P. M.	30·03 falling	rain	
10	light shock	1.47 A. M.	30·10 rising	clear	P. M. of 11th, a heavy rain.
22	severe shock	11.12 P. M.	29·83	clear	Light rain in the morning.
26	smart shock	8.24 P. M.	30·31	cloudy	Raining at midnight.
27	light shock	2.13 A. M.	30·30 falling	rain	16 rainy days during month.
Dec. 14	smart shock	10.37 A. M.	29·99 falling	cloudy	Light rain in the morning.
24	smart shock	7.55 A. M.	30·10	rain	Barometer falling P. M.
1879					
Jan. 3	shock	9.58 P. M.	30·13 rising	clear	
21	shock	3.40 A. M.	30·28 rising	clear	Barometer falling next day, [with rain.
23	light shock	1.45 A. M.	29·80 falling	rain	
26	light shock	4.00 P. M.	30·18 rising	cloudy	
27	smart shock	A. M.	30·25 falling	cloudy	Followed by rain.
28	light shock	1.00 A. M.	29·92 falling	rain	
Feb. 2	smart shock	10.00 P. M.	30·12 falling	clearing	After a light rain in morning.
4	shock	11.00 P. M.	30·14 rising	cloudy	Rain and sleet on the 6th.
27	smart shock	2.45 P. M.	30·34 steady	clear	Barometer falling next A. M.
Mar. 4	heavy shock	4.44 P. M.	29·72		
4	shock	7.00 P. M.	29·74	rain	Rain fell from 1st to 6th.
10	shock	4.35 P. M.	29·76 falling	rain	
10	2 shocks	9.32 and 9.45 P. M.	29·75 rising	clearing	
Apr. 14	light shock	9.20 A. M.	30·14 falling	cloudy	Heavy rain next day.

Date.	Number.	Time.	Barometer.	Sky.	Remarks.
1879					
May 2	2 shocks	2.45 and 2.50 A. M.	30·10 falling	cloudy	Light rain next day P. M.
20	shock	11.28 P. M.	29·92	rain	23 rainy days during month.
Jun. 12	light shock	9.24 A. M.	29·70 falling	rain	17 rainy days during month.
July 18	2 shocks	3.45 P. M.	30·01 falling	clear	Remained clear for 10 days.
24	shock	8.15 P. M.	29·88 steady	clear	[at 9.30 P. M.
Aug. 6	smart shock	8.27 P. M.	29·83 falling		Thunder, lightning and rain
28	light shock	8.36 P. M.	29·93 falling	cloudy	Rainfall for month, ·92 in.
Sept.					No earthquakes: 11 rainy [days.
Oct. 17	2 shocks	1.30 and 2.17 P. M.	30·17 rising	clear	[on the 20th.
18	severe shock	1.52 P. M.	30·33 falling		Light rain next day; heavy
25	light shock	0.40 A. M.	30·00 falling	cloudy	Rain next day.
30	light shock	9.44 A. M.	30·05 steady	clear	13 rainy days during month.
Nov 15	2 shocks	9.39 and 9.40 A. M.	30·08 rising	cloudy	Clearing on the 16th.
Dec. 3	severe shock	7.09 A. M.	29·96		Light rain next day.
1880					
Jan. 6	light shock	4.28 P. M.	29·74 rising	clear	Clear until 21st, and 3 days
19	light shock	1.00 A. M.	30·03 falling		[previous.
Feb. 12	light shock	9.00 P. M.	29·82 rising	clearing	After 4 days of rain.
22	severe shock	5.03 A. M.	29·76	raining	Ceased raining shortly after.
25	light shock	6.40 P. M.	30·44		Barometer fell the next day:
Mar. 5	light shock	4.40 A. M.	30·23	clear	[27th, rain.
21	slight shock	4.39 A. M.	30·00 rise	clear	Rainfall of 1·97 in. on 20th.
29	shock	5.25 P. M.	29·99 steady	clear	Barometer fell at night; rain on 30th.
31	slight shock	11.16 A. M.	29·70 falling	rain	Rainfall of 1·46 in.
Apr. 14	smart shock	4.10 A. M.	30.32 rising		Barometer fell at night: rain.
25	light shock	11.04 A. M.	29·59 rising	clear	Light rain preceding shock.
27	smart shock	9.50 A. M.	30·08 falling	cloudy	Moderate S. W. gale next
May 14	light shock	10.00 P. M.	29·77 falling	cloudy	[day.
23	light shock	2.30 P. M.	29·76 rising	clear	Rain on the day preceding.
June 5	light shock	5.12 P. M.	29·93	cloudy	On 7th, A. M., a heavy rain.
7	light shock	9.50 P. M.	29·33 rising	clearing	
10	smart shock	1.20 P. M.	29·84 rising	cloudy	Light rain next day.
July 15	smart shock	4.00 A. M.	29·99 rising	clear	Light rain on the 14th.
19	light shock	11.55 A. M.	29·87 falling	clear	
19	smart shock	8.24 P. M.	29·83 falling	clear	Followed by 3 days of rain.
25	smart shock	2.05 P. M.	29·70 steady		Light rain at night.
Aug. 6	smart shock	9.27 A. M.	29·96	clear	
7	light shock	1.20 P. M.	29·90 falling		Followed by 6 days of rain.
13	smart shock	4.50 A. M.	29·53 rising	clear	
23	3 shocks	4.26 A. M.	29·80 falling	cloudy	Str'ng S.W. gale on 25th, P. M.
30	light shock	11.16 P. M.	30·02 falling	cloudy	Rain next day.
Sept.					No earthquakes: 10 rainy d.
Oct. 2	light shock	3.11 P. M.	29·95 falling	rain	Typhoon midnight of the 3d; barometer. 28·62; force, 11
Nov. 3	smart shock	5.43 A. M.	29·90 steady	cloudy	[Beaufort scale.
10	smart shock	1.00 A. M.	29·88 rising	clear	Sky very bright.
12	smart shock	6.30 P. M.	30·20 falling	rain	Rain continued for 2 days.
Dec. 20	smart shock	10.00 P. M.	29·90	clear	[S.W. breeze.
23	severe shock	10.57 P. M.	29·72 rising		Barometer fell P. M., with a
28	smart shock	1.30 A. M.	29·80 falling	clear	No rainy days during month.

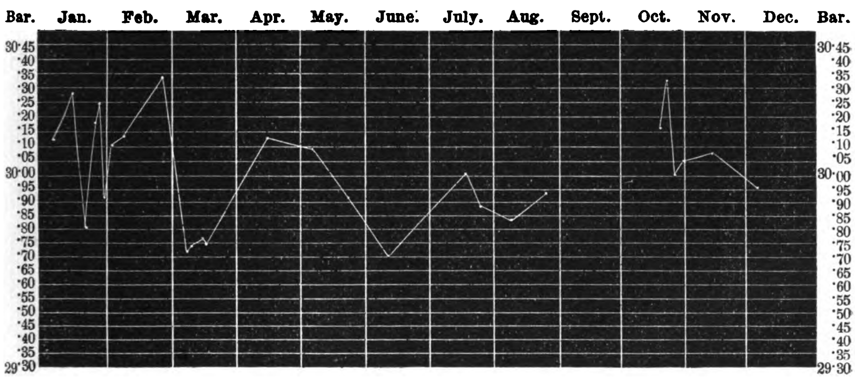
Date.	Number.	Time.	Barometer.	Sky.	Remarks.
1881					
Jan. 7	light shock	6.24 A. M.	29·33 falling	clear	Barom. falling steadily since 3rd; began rising at 9 A. M.; slight snow at 3 P. M.
20	light shock	0.15 A. M.	29·46 rising		Snow on 19th, rain on 21st, fol'w'd by 2 d. cl. weather.
24	smart shock	5.52 A. M.	29·68 falling	clear	At 3 P. M. barometer 29·38, when it began to rise: clear throughout.
24	shock	9.30 A. M.	falling	clear	
27	light shock	4.00 P. M.	rising	clear	
Feb. 7	light shock	4.00 P. M.	falling	clear	
12	smart shock	2.40 A. M.	rising	clear	Rainfall of ·50 in. on 14th; also rained on the 11th.
12	light shock	2.00 P. M.	rising	clear	
28	smart shock	3.14 P. M.	30·13 falling	cloudy	Slight rain next day.
Mar. 8	severe shock	0.17 P. M.	30·34 falling	snow	4·50 in. fell from noon to midnight.
14	light shock	4.15 A. M.	29·80 falling	rain	Fresh wind and heavy rain.
15	light shock	0.26 P. M.	rising		
16	light shock	6.00 A. M.	29·96 rising	clear	
16	light shock	3.00 P. M.	30·01 rising	clear	
17	light shock	2.40 A. M.			
17	heavy shock	4.50 A. M.	30.13	clear	
29	light shock	11.20 P. M.	29·88 steady	clear	Fresh wind next day.
Apr. 11	light shock	10.00 A. M.	30·13 falling		Followed by 3 d. light rain.
18	smart shock	8.00 A. M.	29·59 rising		Followed by clear weather; 1·32 in. rain on the 17th.
26	shock	8.27 P. M.	30·03 falling		Strong S.W. winds, squally, and light rain throughout the month.
May 3	light shock	2.13 A. M.	29·90 rising	cloudy	From 1st to 7th cloudy, with light rain; on 7th a heavy S.W. gale, P. M. clearing.
24	smart shock	1.20 P. M.	rising	cloudy	Only 1 clear d. during month.
Jun. 18	smart shock	10.27 A. M.	29.80 steady	rain	3·30 in. fell to 4 P. M.
July 20	light shock	3.30 P. M.	29·85 steady	clearing	18th and 19th being rainy.
25	shock	11.35 P. M.	29·93 steady	clearing	
Aug.					No earthquakes during the month.
Sept. 3	light shock	10.30 A. M.	steady	clear	From 20th to 30th raining every day; total rainfall for the month, 11·99 in.
Oct. 25	light shock	9.25 P. M.	30·16 falling	rain	
Nov.					No earthquakes this month; total rainfall, 8·50 in.
Dec. 29	light shock	1.00 A. M.	29·96 falling	clear	
31	2 shocks	0.25 P. M.	falling	clear	Clear on the 30th and remained so for several days after the 31st.

CHARTS SHOWING THE RELATION BETWEEN THE HEIGHT OF THE BAROMETER AND EARTHQUAKES. THAT FOR 1881, BEING IMPERFECT, IS OMITTED.

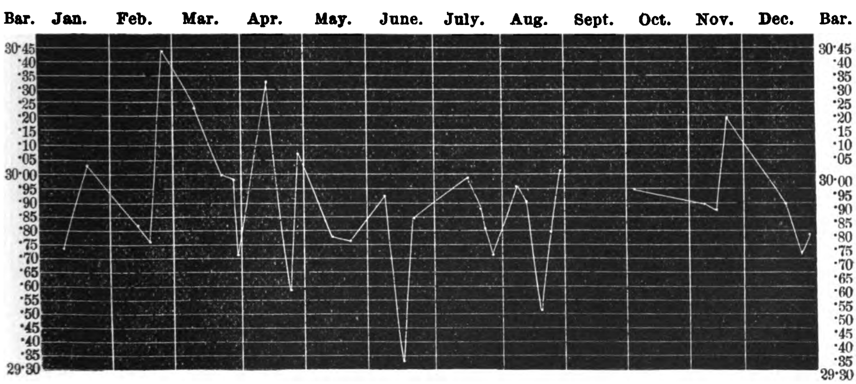
1878.



1879.



1880.



climate of Japan this might imply some relation; but I am inclined to believe that the connection is only incidental. This climate is remarkable for its humidity. In March, 1881, there were nine shocks, and but two of them were associated with any noticeable meteorological disturbance; six were accompanied by remarkably fine weather. On the other hand, in April and May of the same year, we have it recorded of the former that there were light rains throughout the month, and three shocks, and of the latter that there were two shocks and but one clear day. Again, in December, 1880, there were three shocks, two of which are set down as smart, and one as severe, and the month presents no rainy days; and in December, 1881, the two shocks that occurred were associated with fine weather. On the other hand, August and September are remarkable for their excessive humidity. They have the greatest average rainfall, and are accompanied with violent atmospheric commotions; they are likewise periods of earthquake calms. Other inconsistencies might be picked out, but the above will suffice.

"In 1834, Professor Merian, having classed according to their appearance in the various seasons of the year 118 earthquakes which occurred at Basle, and the countries around it, ascertained, to the surprise of the scientific world, that these phenomena are much more frequent in winter than in summer."—(Reclus.) The same results are obtained in the present analysis. They are here arranged as they occurred in the months and seasons:

Dec. 8		Mar. 18		June 9		Sep. 2	
Jan. 15	41 winter.	Apr. 9	35 spring.	July 11	27 summer.	Oct. 10	21 autumn.
Feb. 18		May 8		Aug. 7		Nov. 9	

A gradual decline is noticed running through the seasons. If December be omitted, and March substituted as a winter month, a more remarkable contrast is observed. We should then have 51, or 41 per cent, of the whole number of earthquakes occurring in those three months. February and March are the months of the greatest earthquake activity.

Professor Cleveland Abbé believes that the greater prevalence of the shocks in winter than in summer is dependent on climatological considerations. He says: "If it were an annual period independent of wet and dry climatological seasons, before alluded to, it would be of deep import."—(Earthquake, Appleton's Cyclopedia.) In August, 1878, there were 19 rainy days and a rainfall of 6·62 inches; in September, of the same year, there were 18 rainy days and a rainfall of 17·97 inches, and but one shock occurred, on the 30th of the latter month. In 1879, September had a rainfall of 5·80 inches and

11 rainy days; in August, of the same year, when there were two shocks, there was a rainfall of but ·92 inch. In September, 1880, there were 12 rainy days and a rainfall of 4·67 inches, and no earthquakes; in 1881 there was a light shock on the 3d of the same month, and a rainfall of 11·99 inches. It rained continuously from the 20th to the 30th, but no more shocks occurred until October 25th. March is likewise a wet month, but the amount of rainfall is less than in September. In volcanic regions the rain is thought to supply steam, which may generate an earthquake.

A period of earthquake calm is noticed in either August or September, or the season of the autumnal equinox. During the four years there occurred in the months of August, September and October, 19 shocks, and more than one-half of these are accredited to October. But two shocks occurred in September during the same period, and in the years in which these occurred the period of calm was in August. The most important conclusion arrived at in the present consideration I believe to be this: namely, that the period of earthquake calm is the period of the greatest cyclonic activity. "In Japan, the true typhoon season is restricted to August and September."—(Nature, Oct. 26, 1882, 626.) The barometer shows a similar antagonism between earthquakes and typhoons; the one is associated with a moderately high atmospheric pressure, while the other always accompanies a very low barometer. The northeast monsoon blows from October to April, and the southwest from April to October. Japan is within the influence of these winds. "The transition from one monsoon to another is a critical period, and is always heralded by variable winds succeeded by intervals of calms, and by furious tempests and whirlwinds, proving a general disturbance of the atmosphere."—(Guyot, Earth and Man.) This is more marked in the autumnal than in the vernal equinox. There appears, therefore, to be an even balance between the time of the autumnal equinox and the time of the greatest frequency of earthquake shocks, the one occurring in August and September and the other in February and March, being separated by a period of four months either way. I am aware that this conclusion differs from the opinion usually held, which is, that earthquakes are associated with the equinoctial period of atmospheric disturbance.

There occurred two shocks sufficiently severe to do damage to property, and both of these were in winter, one in December and the other in February. The latter was the heaviest shock that the country has experienced since 1850. No diurnal period is observed, though such a period has been stated by some to exist.

ART. XXXVIII.—*Observations on the fossils of the Metamorphic rocks of Bernardston, Mass.;* by R. P. WHITFIELD.

I HAVE received from Professor J. D. Dana, and from Professors Emerson and Clark, of Amherst and Northampton, Mass., collections of fossils from metamorphic sandy shales at Bernardston, Mass., and also some from a bed of crystalline limestone below them, with a request to examine them with a view to determining their age.

In the shales I find many casts and impressions of Brachiopods, of some of which the generic relations can be determined. Among them I recognize *Strophomena rhomboidalis*, a *Spirifera* (quite abundant), resembling in most of its features *Sp. disjuncta* as it occurs in the Chemung group of New York, but not showing any plications on any of the internal casts, though impressions of a shell having plications of about the same size and form have been detected in several instances among Professor Clark's specimens; two *Rhynchonellas* (common), their relations not determined, although some three or four impressions of one of the species strongly remind one of *R. neglecta* Hall; casts of a *Terebratuloid* shell, resembling very strongly those of the ventral valve of *Cryptonella eudora*, and also a single ventral cast of a *Cyrtina* closely resembling *C. Hamiltonensis*, from the Hamilton and Chemung groups of New York. Besides these there are numbers of undetermined forms, some of which might be classed with *Meristella*, but are extremely uncertain. There is also a cast of a species of *Petraia* or *Streptelasma*, which might represent equally well the species from the Niagara, Lower Helderberg and Hamilton groups.

From the limestone I recognize two species of *Favosites*, and several stems of Crinoids of large size; also from specimens sent to the American Museum of Natural History, by Professor C. H. Hitchcock, a form strongly resembling a species of *Syringopora*, but somewhat doubtful.

The *Favosites* are not in a condition to be identified specifically with certainty. One of them, however, has many characters resembling *F. favosa*, and forms a mass about four inches in diameter by about two in height. The other form is parasitic around a large crinoid stem, and has cells of about the size and form of *Astrocerium venustum* Hall; yet I cannot distinguish in it the peculiar features of that genus.

From the evidence furnished by these specimens I should conclude that the limestones may be of Middle Silurian age, and that the shales were most probably of Middle Devonian

age, the forms mostly resembling those from the New York Chemung group.

In the spring of 1882 we received at the museum a collection of rocks and fossils from near Littleton, N. H., sent by Professor C. H. Hitchcock, who has kindly permitted me to use the evidence furnished by them in this connection. Among them I recognize the corals *Halysites catenulata* and *Favosites Niagarensis*, also a finer form of Favosites which I identified, with but little doubt, with *Astrocerium venustum* Hall, and an undetermined Cyathophylloid coral. There are also many fragments of a *Pentamerus*, which I identified without question with *P. nysius* H. & W. (24th Rept. State Mus. N. Y., p. 184. and pl. x, fig. 1–7 of 27th Rept. State Mus.), a type of *Pentamerus* which ranges from the Clinton to the Guelph limestones, but which is not known above the latter horizon. From this assemblage of fossils there can be no doubt of the Middle Silurian age of these Littleton limestones (probably Niagara); and as they were supposed, from stratigraphical evidence alone, to be the same as the Bernardston limestones before the fossils were examined, I think these are strong reasons for not only making them equivalents, but also for considering both as of the age which I have assigned to them.

Note by J. D. Dana.—The "shale" referred to by Mr. Whitfield is a laminated part of the quartzite which immediately overlies the limestone, and occurs only along the junction, and locally so; the specimens are rusted from oxydized pyrite, and cavernous from the removal *probably* of calcareous material; and in the removal the laminated structure has become apparent. The calcareous material I have attributed to a passage of the limestone in places into the quartzite, the two being, to all appearance, directly consecutive formations. Since the publication of my last paper on this subject, the region has been thoroughly studied by Professor B. K. Emerson of Amherst, and before long he will publish his very important results, and give his final conclusions on the stratigraphical point suggested by the fossils,—which, though very poorly preserved, have great interest on account of the large variety of micaceous, hornblendic, gneissic and other metamorphic rocks occurring in the same series with the beds containing them. Mr. Whitfield's examinations correct my inference as to one of the Brachiopods. Professor Emerson hopes to make further discoveries, that will remove the doubts which still exist, and bring together chronologically the associated strata.

ART. XXXIX.—*Review of DeCandolle's Origin of Cultivated Plants; with Annotations upon certain American Species;* by ASA GRAY and J. HAMMOND TRUMBULL.

PART II.

THE fourth chapter of "*L'Origine des Plantes Cultivées*" relates to plants cultivated for their fruits; the fifth to those cultivated for their seeds. Our present annotations concern a few species or forms of *Cucurbitaceæ*, the history of which has been involved in some obscurity and confusion.

A word, in passing, upon the Peach, upon the history of which this volume throws some new light. DeCandolle had formerly suggested China as its home, and he has brought together additional evidence in favor of that view. He shows how this conclusion goes against an old idea that the Peach is a derivative of the Almond, which is indigenous to western Asia, and was unknown to the Chinese anterior to the Christian era, while they had peaches of various sorts long before. Upon *Pyrus*, there is a note relating to botanical orthography, p. 183, which we append, as it has an application to a few other words.*

Lagenaria vulgaris. Bottle Gourd.—Although doubtless an Old-World plant (DeCandolle attributes it to India, Molucca, Abyssinia), yet it is not quite certain that it had not reached the New World before Columbus. At least the following notes may be put upon record.

M. DeCandolle mentions the case of the name *gourd* for *pumpkin* ("potiron") by English writers, as "an example of the confusion of popular names and the greater precision of scientific names." Such confusion becomes more perplexing when we have to deal with popular names of the 15th and 16th centuries. Parkinson—a good observer and a respectable botanist—complained, in 1640, of "our modern writers who confound *Pepo*, *Melopepo* and *Cucurbita*, so promiscuously that it is not possible to find out the distinct certaintie of them all; for some make that *Pepo* that others call *Melopepo*, and others, *Cucurbita*." (*Theater of Plants*, p. 770.) Scientific names of the 16th century are as obsolete as popular names of the same period. They do not help us to distingush *Lagenaria* from *Cucurbita*, or *Pepo* from *Melopepo;* or "Citrouille" from *Citrul-*

* "L'Orthographe *Pyrus*, adopté par Linné, se trouve dans Pline. *Historia*, ed. 1631, p. 301. Quelques botanistes ont voulu raffiner en écrivant *Pirus*, et il en result, pour une recherche dans un livre moderne, il faut consulter l'index dans deux endroits, ou risquer de croire que les Poiriers ne sont pas dans l'ouvrage. En tous cas le nom des anciens est un nom vulgaire, mais le nom vraiment botanique est celui de Linné, fondateur de la nomenclature adoptée, et Linné a ecrit *Pyrus*."

Pears and Apples were prehistoric in Europe, both wild and cultivated.

lus. Early voyagers to America wrote *cucurbita, calabaça, courge* or *zucca*, as a name for any 'gourd' or pumpkin, and occasionally for a 'calabash' which was not even a cucurbit. The relation of the first voyage of Columbus repeatedly mentions the *calabazas* used by the natives of St. Domingo and other islands for carrying water (Navarrete, *Collec.* i, 180, 188), and, Dec. 3, 1492, Columbus saw, near the east end of Cuba, fields planted with *calabazas* and other productions of the country (*id.* p. 225). Yet we know from Peter Martyr that some of the gourds ("cucurbitæ") used in the islands grew on "cucurbiteas *arbores*" as tall as elms (*Dec.* i, lib. 3, and iii, lib. 4; pp. 38, 246). This tree, *Crescentia cujete*, is described by Oviedo (*Hist. gén.*, lib. viii, c. 4) under its Haytian name, *Higuëro*; in Nicaragua, it was called *Guacal;* and in Brazil, *Cuiete* * (Marcgrav, *Hist. Nat. Brasil.*, 123). J. de Lery (*Hist. Navig. in Brasil.*, 154) describes the tree under the Brazilian name of *Choyne;* but elsewhere (p. 246) he says "the natives have *cucurbitæ* (*courges*) and other kinds of fruits," from which "they make their bowls, called *coui*, and other vessels."

It is certain that *calabaças* which were *not* arboreal, but genuine cucurbits, were abundant—and were believed to grow spontaneously—in the islands and on the main land, before 1526. Oviedo (*Hist. gen. y Nat.*, lib. vii, c. 8) observes that "*calabaças*, in the Indias, were as common as in Spain, and of the same kinds (de las mismas), long and round, or banded (çeñidas), and of all the shapes they usually have [in Spain]." They were much used, "in all parts of these Indias, both the Islands and the Main," and "are one of the common things that the Indians cultivate in their gardens." They were not cultivated for food—"for they do not eat them"—but for carrying water; "and they have other *calabaças*, that are in all respects like the aforesaid, except that they are bitter to the taste; and there are many of these that grow of themselves, without cultivation."† The same author (lib. xi, e. 1) in a list of plants introduced from Spain, names melons and cucumbers (pepinos), but *not* gourds.

The relation of the voyage of Amerigo Vespucci, 1489, in a description of the Indians of Trinidad and the coast of Paria, says that "each carried, hanging at his neck, two small dried gourds (*cucurbitas*), one containing the plant that they were accustomed to chew, the other, a certain whitish flour," etc.,

* Not *Cujete*—unless *j* has the German sound. The Tupi name is formed from *cuï* (*ccu-in*, Lery) 'the shell' or hard rind of a nut or fruit (and the 'bowl' or calabash made from it) and *eté* 'good, precious.'

† M. DeCandolle, p. 198, citing this passage from Ramusio's Italian translation of Oviedo's *Historia Natural*, etc., has "*zucche*" for "*calabaças*" of the Spanish original, and takes no notice of what is said of their spontaneous growth.

and that each woman carried a *cucurbita* of water (Navarrete, iii, 252, 254).

The "Cucurbita lagenæ formâ," which Marcgrav found in Brazil, 1637–8 (*Hist. Nat. Brasiliæ*, 44), though "very probably *Lagenaria vulgaris*," yet, as M. DeCandolle observes, "does not prove that the species was in that country before the voyage of Amerigo Vespucci in 1504;" but we know from Lery, above cited, that the natives of Brazil used *cucurbitæ*, for bowls and drinking vessels, at least as early as 1557. Moreover, the richness of the Tupi vocabulary in gourd-names suggests—if it does not absolutely prove—that several varieties of Lagenaria were known to the Brazilians long before the visit of Piso and Marcgrav. The *Tesoro de la Lengua Guarani* (*o Tupi*) of Father Ruiz de Montoya was first printed in 1639. It gives for gourd (*calabaço*), the Tupi *general* name, *Ia* [which is a compound of *ĭ* 'water,' and *yá* or *á* 'fruit'], and for the varieties—among others—it names *ĭaçĭ* 'round gourd;' *ĭáyurumî* 'narrow-mouthed gourd;' *ĭátĭ* 'long-necked gourd;' *ĭáobá* 'wide-mouthed gourd;' *ĭáquatiâ* 'painted gourd;' *ĭácuîpé* 'spoon gourd' (used for making spoons); *ĭáapê* 'small gourd, used for drinking;' *ĭáquâ* 'great gourd;' *ĭácuî* 'gourd like a great dish' or bowl, etc.: not including the derivatives of *cuî*, or the *edible* "calabaças"—to be mentioned hereafter.

"Acosta, too," says M. DeCandolle, "speaks of *Calebasses* which the Peruvians used for cups or vases, but the Spanish edition of his book is of 1591, more than a hundred years after the conquest." (?) Acosta says *more* than this. After mention of the "Calebasses or Indian Pompions . . . especially those which are proper to the country" [Peru], he adds: "*There are a thousand kinds of Calebasses;* some are so deformed in their bigness that of the rind cut in the midst and cleansed, they make, as it were, baskets to put in all their meat, for their dinner. Of the lesser, they make vessels to eat and drink in," etc. (*Hist. nat. y moral de las Indias; translation, revised by Markham*, lib. iv, c. 19; p. 238).

Cucurbita maxima, C. Pepo, C. moschata. Pumpkin, Squash, etc.—In the Géographie Botanique not one of the cultivated *Cucurbitæ* is attributed to America, and a reference to Nuttall's record that the warted squash was grown by the Indians on the upper Missouri is the only mention of any aboriginal cultivation of squashes in North America. In the present volume, there is merely a reference, in this respect, to Dr. Harris's article in this Journal (xxiv, 1857), and to Mr. Trumbull's note in the Bulletin of the Torrey Club (1876), with the comment that: "Cela nous apprend seulement que les indigènes, un siècle après la découverte de la Virginie, 20 à 40 ans après la colonisation par W. Raleigh, faisaient usage de certains fruit de Cucurbitacées."

Nevertheless *Cucurbita Pepo*, upon botanical indications solely, is attributed to temperate North America in the general table, to a Mexican or Texan origin in the body of the work. This rests upon the collection by Lindheimer, in Texas, of a form of this species, "apparently indigenous." That was between thirty and forty years ago; no wild specimen has since been received from all that region (nor from any other); and it is well nigh certain that the species was commonly cultivated in all that country by the aborigines. If ever found truly indigenous, it will probably be farther south than Texas. *C. maxima* is now set down as from Guinea, on the strength of a single finding of it "apparently indigenous" on the banks of the Niger. *C. moschata* (to which Vilmorin refers the Canada crook-neck Squash) is in the list of species of completely unknown or uncertain origin.

In this state of the case, it is certainly worth while to present the evidence—gathered with much care and pains—which assures us that one or two, and perhaps all three, of these species, and many varieties, were largely cultivated throughout America, from the tropics to Canada, before the voyages of Columbus.

Allusion has already been made (under *Lagenaria*) to the difficulty of distinguishing the genera of *Cucurbitaceæ*, under the names by which they are mentioned by voyagers and explorers of the first century after the discovery of America; and the question of species is particularly difficult. Yet we find abundant evidence—especially as respects North America—(1) that, in various parts of the country, remote from each other, the cultivation of one or more species of Cucurbits by the Indians was established before those places are known to have been visited by Europeans; (2) that these species or varieties were novel to Europeans, and were regarded by botanists of the 16th and 17th centuries, as well as by the voyagers and first colonists, as natives or denizens of the region in which they were found; and (3) that they became known only under American names; one of these names (*Squash*) becoming, in popular use, generic, and two others (*Macock* and *Cushaw*) surviving, as names of varieties, into the present century.

To present this evidence, as nearly as possible in the order of time, we refer, first, to the relation of the first voyage of Columbus. Dec. 3, 1492, entering a small river [the Rio Boma], near the eastern end of the island of Cuba, he found near it a populous Indian village and saw large cultivated fields "planted with many things of the country, and *calabazas*, a glorious sight (que era gloria vella)!" See Navarrete, *Colec.*, i, 225. It is not *certain* that these *calabazas* were not bottle-gourds (*Lagenaria*), but it is, to say the least, highly improb-

able, that the enthusiasm of Columbus would have been so kindled by the promise of a harvest of little value to Europeans.

Oviedo (*Hist. gen. y nat.*, l. xi, c. 1) names among plants and seeds brought from Spain to Hispaniola, "*melones*" and "*pepinos*"—of which imported varieties were already abundant in the island before 1535; the seed of "*cogombros*" brought from Castile had not succeeded so well.

In July, 1528, Cabeça de Vaca found, near Tampa Bay, in Florida, "maize, beans and *pumpkins* in great plenty, and beginning to be fit for gathering." In 1535–6, when passing through Texas, the Indians supplied him with prickly pears and, occasionally, maize; but after crossing "a great river coming from the north"—probably the Rio Grande—he and his companions came to a region having "fine dwellings of civilization, whose inhabitants lived on beans and *pumpkins*"—and, when the season was not too dry for raising it, maize (*Relacion*, 1542; *transl. by B. Smith*, 1871).

In the summer and autumn of 1539, De Soto found the Appalachian country, in western Florida, well supplied with "maize, beans (*fésoles*) and *pumpkins* (*calabaças*);" the pumpkins of Uzachil were "better and more savoury than those of Spain;" there were "fields of maize, beans and pumpkins," not far from Tampa Bay, where he first landed from Cuba; at Pacaha, on the Mississippi the northernmost point he reached (1541), he found, again, "many pumpkins and much maize and beans;" and, still westward, at Coligoa, "beans and pumpkins were in great plenty; both were larger and better than those of Spain; the pumpkins when roasted had nearly the taste of chestnuts" (Oviedo, lib. xvii, cc. 24, 28; *True Relation, etc., by a Fidalgo of Elvas; transl. by Buckingham Smith*, pp. 45, 47, 122, 285). Oviedo writes "calabaças," but the author of the Portuguese *Relaçam Verdadeira* (1557) has, in one or more of the places cited, "*aboboras*."

In 1535, Jacques Cartier, the first explorer of the St. Lawrence, found among the Indians of Canada "grand quantité de *gros melons*, *concombres* and *courges*" (*Bref Recit de la Navigation*, etc., 1545; *reimpr. Tross*, 1863, ff. 24, 31).

Sagard, whose *Grand Voyage du Pays des Hurons* was made in 1642, makes repeated mention of the native squashes ("citrouilles du pays"), which the Hurons raised in abundance, and which he found very good, boiled or baked (pp. 85, 105, 140, 331). In his *Histoire du Canada* (283), he describes the method by which the Indians hastened the germination of the seeds of these "citrouilles du pays," and "raise them with great ease."

Lahontan (*Nouv. Voyages*, 1703, ii, 61) describes the *Citrouilles* of (southern) Canada—"sweet, and of a different kind from

those of Europe, where," as several persons assured him, these would not grow. "They are of the size of our melons; the flesh, yellow as saffron. They usually bake them in the oven, but they are better roasted under the embers, Indian fashion," etc. Lahontan had as little doubt as Sagard had, that these *citrouilles* (cultivated by the Indians of Canada from the time of Cartier, at least) were genuinely "du pays."

As to the Cucurbitaceæ of Virginia, M. DeCandolle admits, "only, that the natives, a century after the discovery of Virginia, twenty to forty years after the colonization by W. Raleigh, made use of certain fruits of *Cucurbitaceæ*" (p. 201). Let us reëxamine the evidence. Captains Amidas and Barlow, in the first vessels sent by Sir Walter Raleigh to the New World, landed on an island in Ocracoke Inlet (now within North Carolina) in 1584. While the vessels remained there, and while they were at Roanake Island near by, the Indians entertained them kindly, and "sent them, commonly every day, a brace of bucks, conies, etc., sometimes *Melons*, Walnuts, *Cucumbers*, Pease, and divers roots" (J. Smith's *Gen. History*, p. 3).

What these "melons," or some of them, were, we learn from later explorers and the first colonists of Virginia (proper).

Capt. John Smith says that the Indians of Virginia (1606–08) "plant amongst their corn *Pumpions*, and a fruit like unto a musk-melon, but less and worse, which they call *Macocks*," etc. (*Gen. Hist.*, p. 29). Strachey, who was in Virginia, in 1610, describes these "*macock* gourds" in nearly the same words (*Trav. into Virg.*, p. 72); elsewhere, he says the "*macokos* is of the form of our pumpions—I must confess, nothing so good,—'tis of a more waterish taste," and he mentions also, the "pumpions" planted by the Indians, and "a kind of *million*" which they "seeth, and put into their walnut-milk, and so make a kind of toothsome meat" (p. 119). "The *Indian Pumpion*, the water-melon, musk-melon," etc., are named among fruits introduced into Bermuda, by the English, before 1623 (Smith's *Gen. Hist.*, 171).*

Among Johnson's additions to Gerarde's Herball, 1636, there

* L'Ecluse (Clusius) heard of these *Macocks* in 1591, or earlier. In his *Exotica* (1605; lib. iii, c. 2) he describes a fruit—"*Macocqwer* Virginiansium, *forte*"—which had been sent him from London by James Garet, brought from "the province of Wingandecaow, which the English call Virginia." He *conjectured* that this might be "the fruit which the natives of that region call *Macocqwer*"—but his figure and description do not favor this identification. The fruit, he says, is nearly orbicular; four inches in diameter; with a hard rind, yellowish on the outside; many seeds, flat and heart-shaped ("cordis, ut vulgo pingitur, formam referentia"). L'Ecluse thought it might be one of the gourds which the natives used for rattles, as the Brazilians used their *Tamaraca*, etc. His specimen was old and dried, the pulp blackened, the rind covered with a dark membrane, "per quam sparsæ quædam fibræ à pediculo ad summum." This must have been a fruit of *Crescentia cucurbitina*, a calabash, which is a native not only of West Indies, but also of Southern Florida.

is a description of "*Macocks Virginiani*, sive *Pepo Virginianus;* the Virginian Macock or Pompion" (pp. 919, 921). The description is dated, 1621, and signed by John Goodyer. The plant has "great broad shrivelled yellow flowers, like those of the common Pompion." The fruit, "somewhat round, not extending in length, but flat like a bowl, but not so big as an ordinary bowl, being seldom four inches broad and three inches long; of a blackish green color when it is ripe. The substance or eatable part, of a yellowish white color. . . . "Seeds like the common Pompion, but smaller." The "small round Indian Pompion," and "the cornered Indian Pompion"—the latter resembling our common "scolloped Squash" ("*Pepones lati*, Broad Melons or Pepons" of Lyte's Dodoens, p. 588) are described and figured in Johnson's Gerarde, p. 920.

Beverley's History of Virginia, 1705, p. 124, mentions the *Macocks*, "a sort of Melopepones, or lesser sort of Pompion or *Cashaw*," which he identifies with the "*Squash* or *Squonter Squash*" of New England. "The Indian name," he says, "is still retained by them." Professor Schele de Vere (of Virginia) states that it still "survives in its anglicized form of *Maycock*" (*Americanisms*, 1871; p. 60).

The *Cushaw* (*Ecushaw*, Hariot) is described by Beverly (Hist. of Virg., p. 124) as "a kind of Pumpion, of a blueish green color, streaked with white when they are fit for use. They are larger than the Pompions, and have a long narrow neck. . . . The *Cushaws* and Pompions they lay by, which will keep several months good, after they are gathered" (p. 152). Bartlett, *Dict. of Americanisms*, notes the name *Cushaw*, "sometimes spelled *Kershaw*," as "Western" for a pumpkin. Beverley's description makes it nearly certain that the variety so named was the (New England) winter "crook-neck" squash—which, five and twenty years ago, might have been seen hanging, by its necklace of flannel "list," in every New England's farmer's kitchen, from early harvest time till wanted for Thanksgiving or Christmas pumpkin-pies.

The Rev. Francis Higginson, who came to New England in 1629, wrote from Salem, a few weeks after his arrival: "Here are stores of *pompions*, cowcumbers, and other things of that nature *which I know not*" (*N. E. Plantation*, 1630); and, again, "We abound with . . . sundry sorts of fruits, as musk-melons, water-melons, *Indian pompions*, Indian pease, beans, and many other odd fruits that I cannot name" (Young's *Chron. of Mass.*, 265). William Wood, who was in New England from 1629 to 1633, says, of the Indians of Massachusetts: "In summer, when their corne is spent, *Isquoutersquashes* is their best bread, a fruit like a young Pumpion" *N. E. Prospect*, p. 76). Roger Williams, 1643, names these "*Askútasquash*, their vine apples,

which the English from them call *Squashes*, about the bignesse of apples, of several colours, a sweet, light, wholesome refreshing" (*Key to the Language of America*, 103). Again, Josselyn (1638–71, *N. E. Rarities*, 57) mentions these "*Squashes* . . . more truly, *Squontersquashes*, a kind of melon or rather gourd, *for they oftentimes degenerate into gourds;* some of these are green, some yellow, some longish like a gourd, others round like an apple, all of them pleasant food boiled and buttered, etc. But the best yellow *Squash*, called an *Apple Squash*, because like an apple, and about the bigness of a Pome-water, is the best kind: they are much eaten by the Indians and the English." But he distinguishes these from the "*Pompions* [of which] there be several kinds, *some proper to the country;* they are dryer than our English Pompions, and better tasted; *you may eat them green*" (p. 91). The last words (here italicized) give a nearly literal translation of the Algonkin-Indian name of Cucurbits,—in the dialect of New England, *asq*, plural *asquash*, 'green things,' or (to be eaten) 'immature.' Eliot, in his version of the Bible (1663) names three kind of *asquash: askoot-asquash*, [=*Askútasquash* R. Williams, *Isquoutersquash-es* of Wood, *Squontersquash-es* of Josselyn, ut supra,] for "cucumbers;" *quonoo-asquash* "gourds" [literally, 'long *asquash*']; and *monaskoot-asquash* "melons."

"Squashes" were first known to the Dutch, by their Algonkin name. Van der Donck, after speaking of the pumpkins of New Netherland (1642–53) adds: "The natives have another species of this vegetable peculiar to themselves, called by our people *quaasiens*, a name *derived from the aborigines, as the plant was not known to us before our intercourse with them.* It is a delightful fruit, as well to the eye on account of its fine variety of colours, as to the mouth for its agreeable taste. . . . It is gathered early in summer, and when it is planted in the middle of April, the fruit is fit for eating by the first of June. They do not wait for it to ripen before making use of the fruit, but only until it has attained a certain size. They gather the squashes and immediately place them on the fire without any further trouble. . . . The natives makes great account of this vegetable." *Descript. of N. Netherlands*, 1656; *transl. in N. Y. Hist. Soc. Coll.*, 2 Ser., i, 186.

Thus far, we have cited, with one or two exceptions, *American* authorities. M. DeCandolle, after mentioning "the three forms of *Pepones* figured by Dodoens, edition of 1557, to which a fourth, *P. rotundus major* was added in the edition of 1616," and a figure of *P. oblongus*, in Lobel. *Icones*, 641, observes, that "the names given to these plants indicate a foreign origin; but, the authors can affirm nothing, in this regard; the less so, because the name *Indian* signifies, either, of *southern Asia* or of

America" (p. 204). A collation of the descriptions of "Pepones" or "Cucurbitæ," given by European botanists of the 16th century, does away with this ambiguity.

Tragus (Hieron. Bock) *De Stirpium Nomenclaturis*, etc., 1552, p. 830, described and figured "*Melo*, *Pepo*, *Cucumis*, and *Citreolus*;" and (p. 832) named, also, *Cucumis sylvestris*. In the next chapter (p. 834) he wrote "De *Cucumere* seu, ut vulgo loquuntur, *Zucco marino*"—with a figure. "Many kinds of strange plants," he says, "have been brought from remote parts, into Germany, in the last few years." Among others, these "*poma æstiva*," of which some are large, some small, some round, some oblong, some sweet, others bitter, of various colors. "Some call these *Cucumeri*, and assert that they are *Turkish Cucumeres*, with which opinion I cannot agree. . . . I call them *Mala æstiva & Indica*," of which he distinguishes four kinds, *M. Indica crocea*, *lutea*, *citrina*, and *nigra*. "Commonly," he says, "they are called *Zucco marina*, because they first came to us from parts beyond the sea, some from Syria, some from *India*, which the names given them attest; for they are commonly called, *Zucco de Syria* and *Zucco de Peru*."

The figure of "*Cucumer marinus*, Ital. *Cocomere marino*," etc., in the *Effigies Plantarum* of Fuchs, 1549, is a reduced copy of Bock's, and substantially agrees with that of *Pepo rotundus* in Lyte's Dodoens, p. 587, which was "called, also *Cucumis marinus*; of some, *Zucco marino*; in French *Concombre marin*, *Pompons Turquins*," etc.

Matthioli, of Padua (*Comm. in Dioscor.*, ed. 1559, p. 292) is more explicit. "There are," he says, "various kinds of cucurbits foreign to Italy, which can be kept fresh far into the winter. They say that these came into Italy *from the West Indies*, whence they are called by many *Indian*. Their taste is sweetish, not so insipid as ours," etc.; and his figure of "*Cucurbita Indica*" agrees with that of Bock's *Zucco marinus* (or "Zucco de Peru") and with Lyte's *Pepo rotundus*.

It is certain, then, that the botanists of the 16th century to whom M. DeCandolle refers, used *Indian*—when applied to varieties of *Cucurbita*—in the sense of *American*. In the 17th century, the evidence is not less direct. Parkinson (*Theatrum Botanicum*, 1640, pp. 769, 770) figures and describes (1) "*Cucurbita lagenaria major*, the greater Bottle Gourd;" (2) "*C. longa*, the long Gourd;" (3, 4) "*C. clypeiformis & verrucosa*, and *Anguria Aegyptiaca*, the Simmel [Scallop Squash], and the rugged Gourd [warted Squash, orbiculate depressed], and the Egyptian Citruell or Watery Million;" (5) *Cucurbita Indica*, *ovalis*, *pyriformis*, *& fere rotundus*, *Indian Gourds*, oval, pear fashioned, and almost round." Of these "Indian Gourds," he says: "There is very great variety of these Gourds (or *Millions*, as

some call them, or *Pompions*, as I may call them) that *came out of America or the West Indies*, from sundry places, both farther south among the Spanish colonies, and nearer hand, in our own of *Virginia*, *New England*, etc." He notes the great variety of size, shape and color, "some as great as our pompions, some as small as an apple, some discolored on the outside, green with whitish or yellowish stripes, . . some also reddish, spotted or striped, and some of a deep yellow."

Piso and Marcgrav (*Hist. nat. Brasilæ*, 1648, p. 44) describe and figure a plant called *Iurumu* [= *Yurumu*] by the Brazilians, and by the Portuguese, *Bobora*. M. DeCandolle, p. 201, is inclined to agree with modern botanists in referring this to *C. maxima*; but, as he remarks, it appears to have been a *cultivated* plant. If introduced from abroad, the name given it by the Tupis was probably formed, by prefix or affix, from that of some native (or naturalized) species to which it had some resemblance. In Montoya's *Tesoro*, 1639, we find *Yuruá* "calabaçillos silvestres," small *wild* calabazas: but the name *Yurumu* did not yet appear. Almost a century before the visit of Piso and Marcgrav, Jean de Lery saw in Brazil (1557) "certains *citrouilles rondes*, fort douce à manger," called by the natives *Maurongaus* (*Voyage*, ed. 1578, p. 217). The Tupi name *morangá* (the first two vowels nasal) denotes a 'handsome fruit.'

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Change of Volume produced by mixing Solutions of Salts.*—Some experiments have been made by Nicol to extend our knowledge of the volume alterations attending the mixture of salt solutions. The solutions employed were molecular ones, consisting of from one to several molecules of salt dissolved in 100 molecules of water. After their specific gravities had been determined, ten times this specific gravity in grams was weighed out, thus giving equal volumes, which were then mixed together. Three distinct classes of salts were employed: (1) those containing the same metal or salt-radical; hence no double decomposition is possible; (2) those containing different metals and salt-radicals and in which double decomposition is possible; and (3) those which may unite to produce double salts. On mixing solutions of KCl and of $NaCl$ of various strengths and in various proportions, contraction took place in amount varying from 3·4 to 99 volumes in 100,000. Diluting these solutions with an equal volume of water, gave a contraction for $NaCl$ of 15·8 volumes; for KCl of 12·0 volumes; of $5NaCl$ (in 100 molecules of water) a contraction of 144·5; and of $5KCl$ one of 135·0. The difference in contraction on dilution between $NaCl$ and KCl is 3·8; and between

5NaCl and 5KCl, 9·5; while the contraction on mixing the two was 3·4 and 9·8 respectively. Moreover, the contraction observed on mixing salt solutions of different strengths, is the difference between the contraction produced by the dilution of the strong one down to the mean strength C, and the expansion due to the concentration of the weak solution up to the mean, E; $C-E=$ observed contraction. Hence $C_{Na}-E_{Na}=99$, and $C_K-E_K=87$, the sum being 186; while $C_{Na}-E_K=92$ and $C_K-E_{Na}=96$, the sum being 188 or practically the same. Where double decomposition is possible, as when 5NaCl and $5KNO_3$ or 5KCl and $5NaNO_3$ are mixed, the contraction was -1 at 20° and $+7$ at 40° in the first case and 29 and 38 in the second; showing that double decomposition has taken place in the latter, since the differences between the results at the two temperatures are practically the same. The result proves unsatisfactory where the formation of double salts is possible, since a change in water of crystallization takes place which produces unknown volume changes. The author therefore concludes: (1) When two salt-solutions, which cannot experience double decomposition, are mixed, a change of volume takes place due to the different affinities of the salts for water. (2) That double decomposition takes place in solution and that the volume change is an index and even a measure of this.—*J. Chem. Soc.*, xliii, 135, March, 1883. G. F. B.

2. *On the Mutual Displacement of Bases in solutions of their Neutral salts.*—In some experiments on the volumetric estimation of the organic bases, MENSCHUTKIN has observed some interesting facts on the mutual displacement of bases from their neutral salts. Aniline, as is well known, shows no alkaline reaction, either in aqueous or alcoholic solutions, when tested with a drop either of solution of rosolic acid or of phenol-phthalein; its salts react acid. If, therefore, an alkali solution be added to the solution of an aniline salt in presence of either of these indicators, no coloration appears; showing that the aniline is set free and a salt of the alkali formed. Finally a point is reached at which a single drop of the alkali develops the color. The aniline salts used were the hydrochlorate, nitrate and acetate. The bases were potassium, sodium, barium and ammonium hydrates, and triethylamine. By means of volumetric solutions of these bases, the amount of acid taken from the aniline was determined and in every case the whole was removed. This complete displacement of aniline by other bases is in entire accordance with Berthelot's principle of maximum work, the heat of combination between these bases and hydrochloric acid being as follows: KHO 13·7 calories; NaHO, 13·7; $(BaH_2O_2)_{1/2}$ 13·8; NH_3 12·3; $(CH_3)_3N$ 8·7; C_6H_5, H_2N 7·4. Hence the theory of Berthollet, that a division of bases takes place under these conditions, is not sustained by these experiments, stronger bases displacing totally the weaker. Nor does Berthollet's theory of mass find any support here. In a second series of experiments, Menschutkin used twice the quantity of aniline salt with the same result. Moreover the reactions took

place equally well in alcoholic solution. Since the heat of combination of triethylamine is next above that of aniline, experiments were next tried on its displacement. But since an aqueous solution of triethylamine shows a decided alkaline reaction, it became necessary to use alcohol as the solvent. The salts used were the hydrochlorate and the acetate. When titered with the normal alcoholic solution of alkali, numbers were obtained which showed the complete displacement of the triethylamine by the alkali; thus again disproving the law of Berthollet. Even ammonia itself shows the same result; solutions of bromide, nitrate and acetate, in alcohol, when titered with alkali solution, showed complete displacement. In titering back, the first drop of hydrochloric acid destroys completely the color of the solution; hence even in presence of a large excess of free ammonia, the acid unites exclusively with the fixed alkali, contrary to the hypothesis of Berthollet. Besides the importance of these facts in chemical theory, the author has founded upon them a quantitative method for the volumetric estimation of the organic bases referred to.—*Ber. Berl. Chem. Ges.*, xvi, 315, February, 1883. G. F. B.

3. *On the formation of Arsenides by Pressure.*—SPRING has continued his experiments on the formation of chemical compounds by simple pressure and now gives the results obtained with arsenic. When zinc filings and pulverized arsenic, mixed in the proportions required by the formula Zn_3As_2, are submitted to a pressure of 6,500 atmospheres, a homogeneous metallic-like block is obtained, crystalline under the microscope and brittle under the hammer. It dissolves completely in sulphuric acid, evolving hydrogen arsenide and leaving only a small black residue. A similar mixture of lead and arsenic gives a homogeneous block of a metallic luster, hard and brittle and which does not clog the file. The arsenide of tin corresponding to the formula Sn_3As_4, thus obtained, is a white metallic mass, brittle with foliated structure, fusible at a higher temperature than tin and difficultly soluble in hydrochloric acid with evolution of H_3As. The cadmium arsenide required three pressings, and gave a brittle metallic mass. No compound of as high a composition in arsenic, Cd_3As_2, could be formed by fusion. Copper combines with arsenic under pressure only with difficulty. After eight pressings a homogeneous metallic mass resulted, brittle and granular, grayish-white in color. Silver acts similarly, giving a bluish-gray homogeneous metallic mass. Arsenic itself, when submitted to 6,500 atmospheres, acquired a metallic luster and a specific gravity of 4·91.—*Ber. Berl. Chem. Ges.*, xvi, 324, February, 1881. G. F. B.

4. *On the Atomic Weight of Yttrium and Lanthanum.*—In 1872 CLÈVE determined the atomic weight of yttrium to be 89·485, the pure earth having been obtained by the partial decomposition of the nitrates and tested by the spectroscope, in which it showed no absorption bands. But since that time terbium has been discovered, or at least established, and Clève has now reëxamined the question. The yttria was purified by repeated partial precip-

itations of the solution of its nitrate by means of oxalic acid, the molecular weight being determined in each fraction. When this became constant, four fractions were obtained, each of which was converted into sulphate and yielded sensibly the same quantity of yttria, 48·507, 48·526, 48·497, 48·494 per cent. As a mean of twelve analyses made on different fractions, the number 48·503 $\pm$0·0029 was obtained as the percentage of yttria in the sulphate. Taking O as 15·9633$\pm$·0035 and S as 31·984$\pm$0·012, the atomic weight of yttrium is 88·9$\pm$0·027. If SO_3 be taken as 80, the atomic weight is 89·02; or in round numbers 89.

Clève has also redetermined the atomic weight of lanthanum. The value which he obtained in 1874 was in round numbers 139. Brauner having more recently obtained 138·28, he was led to repeat his experiments on a purer product. Having about 1·5 kilograms of the mixed oxides, he converted them into nitrates, heated these up to partial decomposition, and dissolved in water; thus removing entirely the cerium and thorium. The solution was precipitated with very dilute ammonia in cold solution. The liquid soon becomes opalescent and lets fall an abundant deposit of basic salt. Seven different fractions were thus obtained, the last of which weighed 150 grams and consisted of lanthanum nearly pure. Its solution though colorless still showed the didymium bands. It was converted into sulphate, and fractionally crystallized. The last products showed no trace of the didymium spectrum and contained 15 grams oxide. Five products of recrystallization were obtained from this, as sulphates. These gave twelve atomic weight determinations, the minimum being 138·07 and the maximum 138·35. Taking the strictly accurate values of O and S, the atomic weight as a mean is 138·019$\pm$0·0246. Taking SO_3 as 80, the value is 138·22; confirming Brauner's results. Clève explains his former value by the great difficulty of driving off all the sulphuric acid in the ignition without producing a trace of dissociation.—*Bull. Soc. Ch.*, II, xxxix, 120, 151, February, 1883. G. F. B.

5. *On the Synthesis of Cryptidine.*—Among the bases obtained from coal tar, Williams found cryptidine, $C_{11}H_{11}N$. Leeds has succeeded in obtaining it artificially. When xylidine-acrolein is submitted to dry distillation, oily drops are obtained having a peculiar odor. About 155 grams of this substance, submitted in fractions of 20 grams, gave a distillate consisting of oily drops mixed with water, having an alkaline reaction. A porous coal remained in the retort. After removal of the water, the oil dried at 100° weighed 11 grams. It was converted into the hydrochlorate, repeatedly crystallized and then decomposed with potassium hydrate. The oil was collected, washed and again dried at 100°. It boiled constantly at 270°, had a reddish color and disagreeable odor. On analysis it gave numbers corresponding to the cryptidine formula. The hydrochlorate crystallizes in fine, thin colorless tabular crystals which sublime on careful heating. The platino-chloride falls in fine yellow needles when $PtCl_4$ in excess is

added to its solution. It is easily soluble in both water and alcohol.—*Ber. Berl. Chem. Ges.*, xvi, 289, February, 1883. G. F. B.

6. *A Text-book on the Elements of Physics*, for High Schools and Academies; by ALFRED P. GAGE, A.M. 414 pp. 8vo. Boston, 1883. (Ginn, Heath & Co.)—This will be found to be, in all essential respects, a very satisfactory book for the use for which it is intended. It presents the fundamental principles of the science with great clearness from the experimental side, and throughout in accordance with modern ideas; it contains much that is fresh in the subject matter, and the illustrations are new and good; in these respects it is a gratifying contrast to some of the more pretentious older text-books.

II. GEOLOGY AND MINERALOGY.

1. *Annual Report of the State Geologist of New Jersey, for* 1882. 192 pp. 8vo.—In the account of "geological work in progress" this Report, by Professor G. H. COOK, treats of the Red sandstone or so-called Triassic formation, the eruptive rocks of Sussex County Iron Mines, Plastic Clays, and Shore Changes. With regard to the Red sandstone it states that the conglomerates are confined mainly to the northwest border, but occur also in the central portion (p. 18), and on the southeastern border (p. 33), and they are calcareous, quartzose and granitic. The sandstone is usually seven-eighths or more of quartz, but contains feldspar, which is often unaltered, and in some cases much feldspar. A long table of strikes and dips is given, in which the directions are all west of north, and mostly between 20° and 50° west. The dips are stated to be in general toward the major axis of a large ellipsoidal area; and the sinking of such an area faster at the center than at the circumference, would, it is said, tend to fracture the strata and so make fissures for the escape of the trap.

In view of the general westerly dip of the beds in the New Jersey area and the easterly in that of the Connecticut valley, and a similar case between an eastern and a western area in North Carolina, Professor Cook expresses his inclination to adopt the hypothesis that "the various areas of the Red sandstone formation east of the Appalachians, from Massachusetts to South Carolina, were once in some way connected, and perhaps also those farther northeast in the British Provinces"; and that this great region of the rocks was afterward broken up into the actual areas by disturbance along "a number of axes of elevation, or else of great faults." As the point is one of much importance in American geology, the writer gives here some facts bearing on it from his own observations, which may be taken as supplementary to the general considerations presented by him in volume xvii, (p. 328), referring to a somewhat similar view.

The subject is in fact *The Origin of the Jura-trias of Eastern North America.*

(1.) The great area, a thousand miles long, if extending from Nova Scotia to South Carolina, covering various regions that

are now a thousand feet or more above the sea-level, must be assumed to have been either under marine waters, or else under the fresh-waters of an immense lake. The deposits, as all admit, are not marine; and too, they are not lacustrine. Those of the Connecticut valley correspond well, in all parts, to those of fluvial and estuary origin; and the others are not widely different.

(2.) The coarse and fine material of the deposits, as first observed by Professor Edward Hitchcock and since by all writers on the subject, came from the rocks bordering the existing areas, and are such as tributaries would have brought in. If the waters spread far outside of their present limits into a great lake, this would not have been true, for these rocks would have been submerged, and could not have contributed much, if any, to the sediments.

(3.) The beds bear evidence of swift currents and slow intermittedly, and often locally distributed, in the varying coarseness and fineness of the beds, answering precisely to the characters of the later valley deposits of the Connecticut; and these are fluvial, not lacustrine, conditions.

(4.) The coarse deposits are most common along or toward the borders of the area, yet are not excluded from other parts, and occur at intervals, not continuously, on these borders. The finer deposits prevail most over the middle portions, but occur also on the borders. The distribution corresponds with the distribution in the modern Connecticut valley—the result of deposition by a great river, and of coarse contributions here and there, especially along the borders, of the valley deposits, by tributaries.

(5.) The materials are the disintegrated crystalline rocks of the country, unassorted by beach action. Feldspar is present as well as quartz, and is generally abundant, and in as fresh a condition as in the neighboring gneiss or granite. It looks as if disintegration had gone on for a long age over the adjoining hills of metamorphic rocks, until loosened materials, scores perhaps hundreds of feet in depth, were made ready for the transporting waters. Disintegration by the rusting of the mica (biotite) is now making, to the east of New Haven, just such granitic sand as constitutes the coarse sandstone of East Haven.

(6.) Some of the more clayey beds contain small nodules and cylinders of limestone which are possibly of concretionary origin, like the common "clay-stones" of clay beds.

(7.) The coarseness of much of the sandstone, the unusual coarseness of the conglomerates in many places, especially on portions of the eastern border, the frequent occurrence of the flow-and-plunge structure in the sandstone, and the general irregular arrangement of the beds, all testify to Connecticut River floods, *much like the flood from the melting glacier*, during part of the era, or else to a succession of such floods.

(8.) Stones six inches to a foot or more in diameter, and small collections of large stones and gravel, often lie *isolated* in the sandstone, and prove that there were not only great floods, but

also ice-floes; for water alone could not make such local droppings among the fine deposits.

The characteristics are, in fact, quite closely those of the *stratified drift* of the valley. The abundant mica and the occasional pebbles of mica schist in the Portland beds (east of Middletown, Ct.) were evidently brought in by a stream from the northeast that flowed over the Bolton region of mica schist. The great and thick conglomerate of Montague and Sunderland, Massachusetts, wonderful for its coarseness, its stones being generally between six inches and three feet in diameter, extending from the junction of Miller's River and the Connecticut, southward, for eight to ten miles and there stopping, has its parallel in coarseness and in imperfect stratification in the remarkable stratified drift about the mouth of Miller's River, and tells as decisively of immense floods entering here the Connecticut valley; and judging from the greater extent of the Triassic deposit, they must have been vaster floods, or else longer continued, than those from the melting glacier. And "occasional masses three or four feet in diameter" (E. Hitchcock) make certain the presence of ice-floes.

So great ice-carrying floods seem to demand for their origin a glaciated condition for the Monadnock region and the White Mountains and other elevations of New Hampshire and New England.

Thus the facts seem to show that the era of the Red sandstone was one of great precipitation, with one or more long intervals of excessive cold. And the character and limits of the deposits are well explained on the view that a large estuary opened up from the Sound to the northern boundary of Massachusetts. This view requires no great movement in the land at variance with the older directions of movements, as would have been necessary for the connection of the Nova Scotia and Connecticut valley area; it merely requires, as the writer long since suggested, that the submerged coast plateau, eighty miles or so wide, off eastern North America, should have been at or near the sea-level. As he has pointed out, the Hudson River *under-sea* channel, crossing this plateau to its outer margin, is probable evidence that this condition formerly existed; it may have existed then (and many times besides) in American geological history.

It is a strong argument, I think, against the supposed cross connection of the areas that they all have a direction parallel to the earlier lines of uplift. The area passing through Pennsylvania has quite precisely the sigmoid form which characterizes fundamentally the courses of uplifts and general topography of the State. The Connecticut and New Jersey lines are in independent valleys, and had their independent origin; and in the Triassic, great movements went on that affected each fundamentally and not the intermediate region, for the valleys were alike in undergoing a gradual and profound subsidence during the period of the deposition of the sandstone, many of the beds bear-

ing evidence of shallow-water origin. An artesian boring at New Haven, now in progress by the Winchester Arms Company, has gone down into the sandstone 1500 feet *below the sea-level* without reaching the bottom of the formation; and, only two miles west, the metamorphic schists rise to a height of nearly 400 feet above the sea. The trough is here, consequently, over 1900 feet deep, and the pitch into it on this western side is at the rate of about 1000 feet a mile; and it may prove to be much greater when the artesian boring has gone down its next proposed 1000 feet. The maximum depth along the center of the trough may greatly exceed the depth near New Haven, whatever the amount. The valley in its independent movements, and its relations to the mountain-making disturbances of older time has nothing to favor the idea of any connection with that of New Jersey in the Triassic era, unless possibly through Long Island Sound; and this, if a fact, would not be of the kind implied in Professor Cook's hypothesis. J. D. D.

2. *Life of Sir William E. Logan*, Kt., LL.D., F.R.S., F.G.S., etc., First Director of the Geological Survey of Canada, by BERNARD J. HARRINGTON, Ph.D., Professor of Mining in McGill University, late Chemist and Mineralogist to the Geological Survey of Canada. 432 pp. 8vo, with steel portrait and numerous wood-cuts. Montreal, 1883. (Dawson Brothers.)—It was well for American geology that Sir William Logan was made Director of the Geological Survey of Canada. A man of patient, thorough, thoughtful research, of great precision in all his labors, sure in his steps of progress as far as this was possible in a region of so great complexities, and cautious in expressing his views, he was admirably fitted for work at the foundations of the science in America; and his results have proved to have the best of qualities; they stand, and American Geological Science is being built upon them. The "Azoic rocks" had been previously recognized; but Logan was the first to make known the structure, system of flexures, thickness, and other characteristics of the long series of schistose rocks, and trace out and map the folded strata of limestone they include, so as to give intelligible shape to these bottom terranes of the geological series.

The Green Mountains, and the country subordinate to them on the west with the included Taconic range, had previously been the subject of partial investigation and much speculation. But Logan found a starting point for new investigations in his Canadian discoveries, and thence worked, with his usual care, southward, over this field of metamorphic rocks to the Highlands of Putnam County, tracing the positions and relations of the various upturned beds; and he ended in establishing, in his view, the Lower Silurian age of the main system of beds, the Taconic group included, and their unconformability to the Highland Archæan. The fossils of the Canada starting point were of the so-called Quebec Group, which he described in 1863 (Rep., p. 233), after the study of the fossils by Billings, as "a great development of

strata about the horizon of the Chazy and Calciferous formations;" and he referred the various beds of the Green Mountains and Taconic region to this particular group. Subsequent discoveries of fossils in Vermont, and elsewhere, have determined that other parts of the Lower Silurian are represented, from the Primordial to the Trenton and Hudson River group inclusive; but they only modify and extend his general result. He found the limestones, the associated metamorphic schists, and the quartzyte (Sillery sandstones) *conformable* in Canada and along the Green Mountains; and the writer of this notice has observed the conformability *in superposition* between the quartzyte and the same associated formations in many sections through the States of Vermont, Massachusetts and Connecticut,—so thoroughly sustaining Logan's sections, that any apparent exceptions found since in Canada are necessarily of only local importance. As in Canada, so to the south, the quartzyte often *overlies* (sometimes nearly horizontally) the limestone and schists; but whether so through overturns or not is unsettled.*

In the course of the writer's explorations of Berkshire (Massachusetts) he was told, when at one of the hotels, of an unknown man of gray hairs stopping there for a while some years before, who was off on foot each morning after an early breakfast, hammer in hand, and returned, laden with specimens, at dusk: it was Logan in 1866, studying the question as to the relations of the limestones and the associated rocks.

The large, colored, Geological Chart of Canada prepared under Logan's direction, embodying the results of his survey and also—through the aid especially of Professor James Hall—the distribution of the geological formations over the Northern United States down to Central Pennsylvania, is another great work by Logan, of vast service to the geological science of the country. It is the only American geological map yet published that in exactness and fullness of detail and style of execution compares favorably with the best charts of the countries of Europe.

Dr. Harrington's biography of the able geologist gives a highly interesting sketch of his early life; his scientific studies and discoveries in England; his appointment "on recommendation of De la Beche, Murchison, Sedgwick and Buckland" to the position of Director of the Geological Survey of Canada; his various explorations, and the methods and results of his survey; his artistic sketching in his note-book; and a delighting exhibition of the man among men as well as at his work. An appendix contains a valuable article on the Quebec Group by Principal Dawson, and a list of Sir William Logan's more important publications. J. D. D.

3. *On the Utility of the Method of the Pennsylvania State Geological Survey in the Anthracite Field.* Extracts from a paper by BENJ. SMITH LYMAN (late Geologist of Japan), read before the American Institute of Mining Engineers in February.

* The writer has in progress an investigation bearing on this point.

The Atlas* of the Panther Creek basin, in thirteen sheets (of 32 inches by 26), the first published result of the State Geological Survey of the Anthracite Fields of Pennsylvania, by Mr. Chas. A. Ashburner, Geologist-in-charge,† and several assistants, under the State Geologist, Professor J. P. Lesley, deserves attention from its great beauty, its high scientific value, the novelty of its methods of illustration, and the vast amount of practical instruction conveyed.

What is chiefly wanted from such a survey is of course direct or indirect aid toward turning to man's benefit the resources of nature, and in this case toward facilitating the mining of anthracite. Evidently nothing can help in that way more than a clear, trustworthy indication of the precise position, and the amount, of each workable bed of the coal, an answer to the questions: How much coal is there? where is it? at what depth? with how steep a dip? in what direction? with what basins and saddles of what length, breadth, depth or height? in what direction would level drifts run? where would the coal be best attacked by shafts or drifts? what beds of rock or coal lie above or below the coal worked, and at what distance? what is the situation of the coal with reference to water courses or other features on the surface of the ground? and the like; and it is easily conceivable that it would be impossible to give indications of this kind so fully and satisfactorily with a whole volume of words merely, as with a properly constructed map. Thirty years ago, Professor Lesley devised and brought into use a method of representing such geological facts, by a topographical map, with contour lines, and with the outcrop of certain beds and the course of a single level upon them, say the lowest water level of a tract.‡ But three of the present sheets are drawn in a somewhat improved way, showing more thoroughly the whole position and detailed structural shape of a coal bed by numerous curved lines equidistant in level, like the contour lines of surface topography. The result is a complete and satisfactory geometrical construction of the bed upon paper, leaving nothing further to hope for in precision and clearness and compactness of working information. The method has never before been applied to so large a field, with such completeness in minute details.

* The State price of this atlas is $1.50, and it can be obtained either in rolled sheets in a pasteboard tube or folded sheets in an octavo pocket, by addressing F. W. Forman, Clerk of Survey Commission, 223 Market Street, Harrisburg.

† Mr. Ashburner was placed in charge of the Anthracite Survey in August, 1880, when a reconnaissance of the coal fields was commenced. In the following November a plan was submitted to Professor Lesley for mapping the coal basins. This plan was adopted by the Board of Commissioners, and was briefly described by Mr. Ashburner before the American Institute of Mining Engineers, February, 1881 (Trans. vol. ix, p. 506). On account of a failure in the Survey appropriations the Anthracite Survey was not regularly organized until July, 1881, since which time the work has been vigorously pushed forward. On the first of last January the field work in one third of the region had been completed. It will probably take four or five years to complete the survey.

‡ Mr. Lyman has used this method of representing geological structure on his Japanese maps, but not in so precise a way as is done by Mr. Ashburner.

The general facts disclosed about the shape of rock-beds are novel even to experienced geologists. It is here seen that beds of coal and other rocks are folded together with much less uniformity of shape than had hitherto been supposed, as irregularly in fact as a carpet crumpled together by a push from one side. Another feature noticeable is the absence of faults in a region that has been very much disturbed and has some overturned dips.

With such maps as these it can be seen where drainage adits or other levels may be driven; where and at what depth shafts will strike a given coal bed; what portions of a mine underlie buildings on the surface; in short all the principal geological requirements for working a mine are plainly set forth; and money need not be wasted (as many hundreds of thousands of dollars have been) in groping blindly for a coal bed, with digging according to the necessarily inaccurate guesses or opinions of even the clearest-headed or most confident miner.

In addition to the extremely valuable and elaborate underground map of the surface of the Mammoth Bed, on a scale of 800 feet to an inch, there are three sheets of twelve cross sections of the basin at different points, on a scale of 400 feet to an inch, showing the several coal beds in their relative position and distance apart wherever positively known, together with twelve cross sections at the same points on one-fourth the scale, to show the connected structure of the Mammoth coal bed, whether actually seen throughout or not; and a small skeleton map of the basin (3200 feet to the inch) to show the places of the sections. All these sections across the basin are on the same scale vertically as horizontally, and hence show the geological structure undistorted, which is of course their true object.

But on such cross sections of the structure the scale has to be too small to give many details of the thickness and composition of the beds of coal and rock; and moreover the full sequence of beds cannot be seen at any one point. On two other sheets, therefore, the coal beds are drawn on a much larger scale, forty feet to an inch, in seventeen columnar sections at different parts of the basin, showing the true relative order, thickness and distance apart, of all the important beds, whether of coal or of rock of different kinds. On the same sheets are added five similar columnar sections, on a smaller scale (100 feet to the inch), of the Pottsville conglomerate underlying the set of workable coal beds; and besides, a diagram, on a scale but one-third as large, of twelve columnar sections of the Pennsylvania Geological Formation, No. XII, and up to the Mammoth Coal Bed; also a convenient repetition of the little skeleton map to show the places of the sections. Such sections of course, if compared with what is found in a shaft or boring or in natural exposures, show how vain it would be to dig for workable coal at many a point where perhaps a small streak of coal or black slate, or dark colored earth, may (as so often has happened with consequent immense loss of money) create, for a time, illusory hopes of discovering a valuable coal mine.

The scale, however, of these columnar sections is too small to show certain features of a coal bed of great importance in working its different layers; and so there is a sheet with twenty-eight columnar sections of coal beds on a scale of ten feet to an inch; including that marvel, the Mammoth bed, at one point over 114 feet thick, with nearly 106 feet of coal and the rest several layers of slate. On the same sheet there is in addition a diagram (200 feet to the inch) of seventeen columnar sections, side by side, to show the true relation to each other of the coal beds known, and sometimes differently named, at different parts of the basin. Such identification of the beds of different mines is plainly of very great importance in giving a knowledge of what beds may be expected to be found above or below a bed that is actually worked; for an error in naming one bed may lead to enormous pecuniary losses from the mistaken views it may engender in regard to what is above or below.

Another sheet gives a topographical map of the surface on a scale of 1600 feet to an inch, half less in scale than the underground map, and with contour lines every ten feet.

To give a knowledge of the situation of the basin with reference to the whole anthracite region, a sheet is added with a general map of the northeastern corner of Pennsylvania, on a scale of nearly five miles to an inch, showing all the different fields in their relative position. On the same sheet there are eleven columnar sections, on a scale of 300 feet to an inch, to show the coal beds of the different basins and their relation to one another. It is striking here how variable is the number of coal beds in the different sections and at what variable distances apart. The sheet has further a list of the 340 collieries in operation, with their yield in 1881, amounting in all to thirty and one-half millions of tons.

The total annual yield of anthracite year by year from the beginning is given on a separate sheet, divided, too, in separate fields, and illustrated with a large diagram of pyramidal shape of the kind published for many years by Mr. P. W. Sheafer.

With such enormous drafts upon the fixed deposit of coal the very weighty question presses forward: how long before the whole amount will be exhausted? It is of course impossible to foresee what may be the future increase in the yearly demand; we can only judge more or less approximately by such tables and diagrams as these from what has taken place in the past. But with materials of the kind supplied by the present atlas we can ascertain how large the amount of coal is that we are drawing upon; for on the underground map the actual extent of the Mammoth Coal Bed and of its comparatively small portions hitherto worked out is given, and the columnar sections show by what thickness of coal the area of the bed is to be multiplied to find its amount. A separate sheet is given to the illustration of the method of calculating the complete area of the coal bed in spite of its inclination at different points and even of its overturned condition in

some places. The drawing shows both the horizontal extent of the bed as it now lies and the space it would take up if flattened out. The same sheet has tables of figures to show the extent of the different workable coal beds in the basin.

Every Pennsylvanian and American, directly or indirectly interested in the anthracite lands or mines, or in the price of anthracite, or iron, or other articles for which anthracite is largely consumed, must look with impatience and patriotic pride to the completion of a survey that has so practical and forcible a bearing upon the mining of so valuable a fuel. All interested in geology cannot fail to await with eagerness and great anticipations the rest of the Anthracite Survey's publications, begun by a work of so great value and of so superior plan and execution.

A good survey, however laborious it may be, costs but a trifle compared with the great sums that are often cheerfully spent by the ignorant for trials by digging that give nothing like completeness and definiteness of result. Even if the separate mine owners should carry out such surveys, each at his own expense (as it might be urged they ought to), the results would be far less satisfactory and valuable than can be obtained from a combination of the whole field, for the facts seen on one tract help greatly to elucidate those of another. Moreover the expense of such separate surveys would be much more, an expense that must ultimately be borne by the consumers of the coal. Furthermore, the expense of a combined, or State survey is infinitesimal compared with the value of the coal whose mining is facilitated and cheapened. The present Geological survey is in fact managed so economically that all the field and office work for the whole State costs each year less than one-sixth of a cent on every ton of anthracite yearly mined, and of this sixth the outlay for the anthracite survey is little over a third.

4. *Bulletin of the U. S. Geological Survey.* No. 1.—This first number of the Bulletin of the United States Geological Survey, contains the valuable paper by WHITMAN CROSS, on Hypersthene andesite and on triclinic pyroxene in augitic rocks (see an abstract in this Journal, xxv, 139), with a geological sketch of Buffalo Peaks, by S. F. Emmons, Geologist-in-charge of the Rocky Mountain Division.

5. *Palæontology of the Geological Survey of New York.* Vol. v, Part I. *Lamellibranchiata*, by JAMES HALL.—This quarto volume contains the plates of the Lamellibranchs of the Upper Helderberg, Hamilton and Chemung groups, eighty in number, all of which are well executed, along with explanations of the plates. No descriptions are given excepting brief characters of the new genera proposed. These plates were lithographed several years since, and 3,000 impressions, the usual number, were struck off by order of the State. The text has been ready for publication, but for more than three years no printing has been done on the Paleontology, the needed appropriation by the legislature not being made. Descriptions of the species will probably

appear in the publications of the State Museum in the course of the year, but all is uncertainty as to the appearance of the text of volume V. in the Paleontology. The delay works evil to geological science by impeding the work of others who need to use the results in the study of the fossils of other States, and by hindering the progress of the science in this and other countries.

6. *North American Fossil Mammals.*—In the March number of the American Naturalist, Professor Cope has an important paper on the Extinct Dogs of North America, with many illustrations; and in that for April, a continuation of his memoir on the Extinct Rodentia.

7. *Annelid Remains from the Silurian of the Isle of Gotland;* by G. J. Hinde. (Communicated to the Swedish Academy of Sciences, Sept., 1882.)—Mr. Hinde has continued his discoveries of Annelid remains from Canada and England to the Island of Gotland. The specimens described in this paper from the latter region are numerous, and their figures cover three plates. He observes that the nearest living representatives of these ancient Annelids are those in the family of the Eunicea, an opinion sustained by Professor Ehlers, the principal authority on living Annelids.

8. *A Review of the non-marine Fossil Mollusca;* by Charles A. White. 144 pp. large 8vo. Extract from the Annual Report of the Director of the U. S. Geological Survey, 1881–1882, Washington, 1882.—This review is one of great geological importance. The subject is discussed as regards some of its points by Professor White in volumes xx and xxiii of this Journal (1880, 1882), but is here treated with fullness, and with reference to formations of all ages.

9. *Second Report of the State Mineralogist of California,* from December 1, 1880, to October 1, 1882. 288 pp. 8vo, with an Appendix of 226 pp. Sacramento, 1882.—This second Report by Mr. Henry G. Hanks, State Mineralogist of California, contains a statement of the work accomplished by the Mining Bureau since December, 1880, in the collecting and arranging of a State Museum at San Francisco of the various mineral products of the State, and also in the analysis and determination of minerals, and otherwise in giving information as called for. The Report also contains several papers on general subjects, in which much useful information has been brought together. The first and most extended of these is devoted to the subject of placer mining. It describes the development of this kind of mining, and gives with much detail the successive steps involved, from the preparation of the storage reservoir to the final assaying of the gold extracted; numerous tables are added, giving facts in regard to the flow of water through pipes, through nozzles of different sizes, and other kindred points. This memoir also contains various other points of interest, as the size of the larger gold nuggets found, tables of the average yield of gold for different mines, and so on; it closes with a brief statement in regard to the pro-

duction of gold at foreign localities. Some of the other topics discussed in the report are: the iron ores and iron industries of California; lumber and fuel; the occurrence of salt and its manufacture; mud volcanoes and Colorado Desert; diamonds in California. The Appendix contains papers on the forest trees of California by A. Kellogg; notes on hydraulic mining by F. W. Robinson; on hydraulic and drift mining by Henry Degroot; on the milling of gold quartz by Melville Attwood; on rare minerals recently found in the State by W. P. Blake; on flour gold by A. B. Paul.

10. *Zur Kenntniss der vulcanischen Gesteine und Mineralien der Capverd'schen Inseln von* Professor Dr. C. Doelter. 94 pp. Graz, 1882.—The author has published in another volume the results of his topographical and geological examination of the Cape Verde Islands. The present memoir is devoted to a detailed description of the various volcanic rocks collected and studied by him and of the accompanying minerals. As older eruptive rocks are recognized: foyaite, syenite, diorite and diabase; as younger eruptive rocks: leucitite (rare), phonolite, tephrite, basanite, plagioclase-basalt, nephelinite, nepheline-basalt, limburgite, pyroxenite. The author has applied the various modern methods to the examination of the different rocks, and his descriptions are hence unusually complete; he thus gives not only the constituent minerals and their composition in each case, but also the percentage amount in which they enter. The rock called *pyroxenite* is described as a limburgite, or magma-basalt, without olivine, in other words, a rock consisting essentially of augite, magnetite, and a glassy base, with, as an accessory, haüynite and rarely plagioclase, nephelite and olivine.

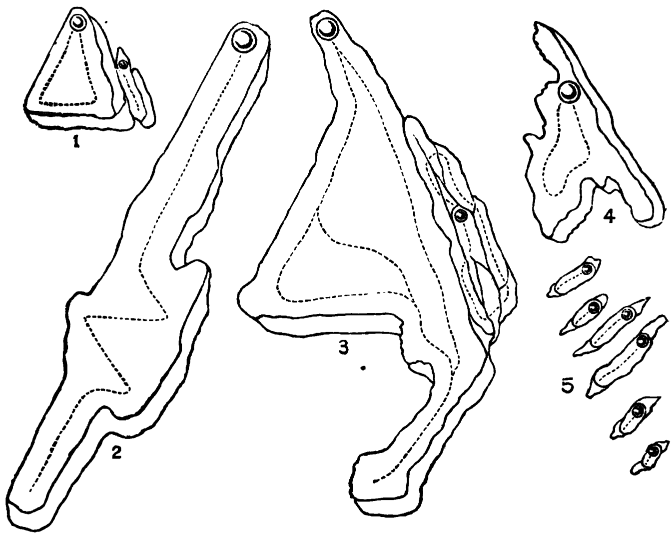
As a secondary mineral, occurring at several spots on the island of Santo Antonio, in crevices on the lava, the author describes a new member of the alum group, under the name of *Dumreicherite.* It forms crusts on the lava, with fibrous structure. An optical examination showed it to be probably monoclinic; this result was confirmed by a study of the form of the crystals obtained artificially from the solution of the mineral. It is easily soluble in water, taste astringent, fuses in the water of crystallization. An analysis by F. Kertscher gave:

SO_3	Al_2O_3	MgO	H_2O	
36·65	7·14	11·61	45·01	Na, Cl tr. = 100·41

The calculated formula is $4MgSO_4 + Al_2S_3O_{12} + 36$ aq.

11. *Fluid-bearing Quartz Crystals.*—Mr. W. E. Hidden has recently described a remarkable occurrence of quartz crystals containing fluid inclusions from Alexander County, North Carolina. A single pocket was found, seven feet long, and about three feet in width and depth, which afforded over four hundred pounds of choice quartz crystals, and including all grades, about half a ton. It was from this pocket that the remarkable emeralds previously described (see vol. xxii, 489) were obtained. The cavity was lined with red mud, and the quartz crystals, except at the bottom, had

become detached by process of disintegration and were imbedded in the mud. The crystals containing fluid cavities were of citrine-yellow to chocolate-brown color, transparent, and of high luster; they were implanted upon the crystals which had been directly attached to the walls. The cavities were of unusual size; the longest had a length of two and one half inches; others an inch in length were not uncommon, and those of smaller size were too numerous to be counted. The accompanying figure shows



some of the cavities of natural size; the fluid contained was water with also some liquid carbon dioxide. Unfortunately this remarkable collection of water-bearing crystals was left exposed to a temperature below the freezing point during a night in the late autumn; by the freezing of the enclosed water the crystals were shattered and reduced to fragments, which were in some cases frozen together to a coherent mass. The ice formed was believed to be due in part to the condensation of the moisture of the surrounding atmosphere by the cold produced by the sudden expansion of the carbon dioxide liberated.

III. Botany and Zoology.

1. *Essay on the Development of the Vegetable Kingdom, especially on the Distribution of Floras since the Tertiary period: Versuch einer Entwicklungsgeschichte der Pflanzenwelt, insbesondere der Florengebiete seit der Tertiärperiode;* von Dr. Adolph Engler, Ord. Professor an der Universität Kiel. 8vo. 1879, 1882. Leipzig, W. Engelmann.—This interesting treatise is in two parts, or volumes; the first, published in 1879, discussing the develop-

ment and distribution of the extra-tropical floras of the northern hemisphere; the second, issued in 1882, those of the southern hemisphere and the tropics: the whole in a little less than 600 pages, full index included. It is a more succinct work than its predecessor, *Der Vegetation der Erde nach ihrer klimatischen Anordnung*, of the late Prof. Grisebach, is conceived in a different manner and developed in a more modern spirit. It may rather be said to take up the lines where Alphonse de Candolle left them at the close of his *Geographie Botanique Raisonée*, in which he reached the conclusion—which the scientific world had then just come to—that the present character and distribution of the actual vegetable kingdom, though ruled by climatic and geographical conditions, was to be explained only by a consideration of the preceding vegetation, namely, that of the tertiary period. Beyond this general proposition, DeCandolle was then (in 1855) not able to go. The *Origin of Species* had not appeared. And as respects the northern hemisphere and its floras, where the key to the mystery was to be sought, Heer and Unger were reviving in this interest Plato's idea of the Atlantis. But the very next year, 1856, the first memoir of the present writer was published (Mem. Amer. Acad., vol. vi), and what Nathorst and Saporta unite in pronouncing "the true solution of the problem," was brought to light.*

From these lines and from the doctrine of natural selection proceed the "leading ideas" of Dr. Engler's work, formulated in thirty-six propositions in the introduction, and applied in the first volume to the elucidation of the distribution of the vegetation of the temperate part of the northern hemisphere. This part opens with a good sketch of the development of the North American flora, from the Miocene down to the Glacial period, treating first the Miocene of the arctic, then the distribution of North American forest during the Miocene, and its gradual transformation

* Ann. Sci. Nat., ser. 6, xv, 153.—Count Sarporta adds in a foot-note that "Asa Gray was not the only botanist who had the idea of explaining the presence of disjoined species and genera, dispersed across the boreal temperate zone and the two continents, by means of emigrations from the pole as the mother region, whence these vegetable races had radiated in one or several directions. This had been *parallèlement* conceived and developed in France, upon the occasion of the remarkable works of Prof. O. Heer," etc.

The parallel memoirs there referred to are one by Count Saporta, published in 1872, and one in 1876 by the same author, in conjunction with Dr. Marion. The first of these appeared in the same year with "Sequoia and its History: an address of the retiring President of the American Association for the Advancement of Science," August, 1872: but the initial memoir, in Mem. Amer. Acad., vi, 1856, preceded the publication of Heer's researches upon the arctic Miocene flora, and had the advantage—or disadvantage—of developing the principal ideas from a consideration of the existing vegetation only,—not so well, indeed, as has since been done; but now that these views are completely adopted, it is perhaps worth while to reproduce these dates. The explanation (given in 1878) for the extinction of Tertiary elements of the flora in Europe, which have been preserved in North America and Asia, is recapitulated by Nathorst, as likewise by Wallace, in his Island Life (pp. 119 and 120), in the latter case without allusion to its source.

into the present vegetation and segregation into the present floral regions. The relations of this flora to that of N. E. Asia and to that of Europe are then very briefly illustrated; and farther on, after a consideration of the eastern and central Asiatic floras in the Tertiary and later, the exchange of floral elements between Asia and North America is well discussed. Some addition to the interest of these topics might have been drawn from the papers of 1872 and 1878, alluded to in the preceding foot-note, both of which were printed in this Journal (the former without the comparative lists given in the official edition), but they seem to have escaped Dr. Engler's attention.

Succeeding chapters treat of the European floras, ancient and modern; upon the development of the high mountain flora before, during, and since the Glacial; upon the more important migrations during the Glacial period; and upon the high mountain floras of North America, illustrated by some good lists, in which, however, alpine plants need to be discriminated from those which are no-wise alpine. Important, also, are the closing sections of the first volume, on the influence of the Glacial period upon the vegetation outside of the mountains, and on the localization of glacial plants. This volume has a colored chart showing the distribution of land and water in the northern hemisphere during the Miocene; the second volume, one illustrating the floral provinces, outlined in the last chapter of the work, as defined on the one hand by climatic features, on the other by their physiologically characteristic groups of plants, i. e., those whose adaptive characters in various ways fit them for the particular district, whether arid or moist, hot or cold, equable or extreme.

In a notice like this we naturally turn only to those parts of the work which most interest us. Our limited space and time preclude even an abstract of the contents of the second part of this work, which cannot be less interesting than the other, and apparently has more novelty of treatment. Our purpose is served by making known to American naturalists and students a volume which they will wish to possess and be sure to value,—the latest text-book upon the subject, and one well up to the time.

A. G.

2. *Bidrag till Japans Fossila Flora;* af A. G. NATHORST. (From "Vega-Expeditionens Vetensk. Arbeten," ii, pp. 121–225, tab. 4–19, 8vo, 1882.)—This paper, one of particular interest to us, should have had an earlier notice, and would naturally have received it from our veteran phytopaleontologist. After a wistful glance it had here been laid aside, awaiting the chance of a translator from the Swedish, and so forgotten, until the preceding note was written, by the opportune help of a French abstract published in Ann. Sci. Nat., tom. xv, 1883, by the Marquis Saporta. The fossil remains which form the basis of this memoir were mainly collected at a place called Mogi, not far from Nagasaki, and their special interest lies in the fact that they presumably represent the vegetation of the locality at a period "not more ancient than later

Pliocene, and not later than the middle of the Glacial epoch." Saporta has drawn up his catalogue of the remains under two heads, the first of fairly determinable plants, with generic and specific names, fifty-one in number. Among them he identifies a *Betula* near to our *B. lenta*, *Ostrya Virginica*, *Fagus ferruginea*, *Vitis Labrusca*, and a *Magnolia* allied to our *M. acuminata* or *cordata*. Among the indeterminable leaves are some resembling those of *Carya amara* and of *Quercus aquatica*. Of species identified with or nearly like living Japanese species, a *Zelkova*, two species of *Styrax*, *Deutzia scabra*, *Acer pictum*, *Dictamnus Fraxinella*, and *Stuartia monadelpha*, may be mentioned. The bearing of this evidence, as supplementary to that furnished by earlier deposits, upon the explanation of the intimate and peculiar relations existing between the actual North American and northeastern Asian floras, is obvious, and is well discussed by Nathorst in this paper, the *generalia* of which are now made accessible to us in the French abstract for which Saporta is to be heartily thanked. The thirteen plates of these fossil plants are in quarto.

Let us add our acknowledgments to the author for a copy of the elaborate and important memoir (in the Transactions of the Royal Academy of Sciences at Stockholm) by Nathorst, upon the tracks made by invertebrate animals, and other traces, which simulate Algæ, being the memoir which called out Saporta's paper, recently noticed in this Journal, p. 235. It is illustrated by numerous wood-cuts in the letter-press, and by eleven fine photographs in quarto, and, moreover, is made accessible by an appended translation into French. with some additions. A. G.

3. *Structural and Systematic Conchology.* By GEORGE W. TRYON, Jr., Vol. I, 8vo, 312 pp., 22 plates. Philadelphia, 1882.—This work is intended as a manual of Malacology. It is, as stated by the author, almost entirely a compilation, both as to text and figures. The principal sources from which it has been compiled are Woodward's Manual of the Mollusca, and Dr. Fischer's Manuel de Conchiliologie. Mr. Tryon's work is much inferior to Dr. Fischer's, both in matter and execution. The author has attempted to combine the antiquated ideas of classification that prevailed twenty-five years ago, with those that have been brought forward by the more accurate and elaborate investigations of modern malacologists. The result, as might have been expected, is heterogeneous and incongruous. Inasmuch as there is no good conchological manual in the English language more modern and comprehensive than Woodward's, which is now antiquated, it is to be regretted that Mr. Tryon's has not been executed with more care. Nevertheless, it will undoubtedly be found very useful by a large number of persons to whom the larger and more elaborate works are not accessible. The present volume includes chapters on anatomy, habits, geographical and geological distribution, nomenclature, classification, and collecting. V.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Report of the Superintendent of the United States Coast and Geodetic Survey for the year ending June,* 1880.—This report exhibits in a striking manner the extension of work expressed in the change of name of the Survey by the addition thereto of *Geodetic.* The carrying of the primary and secondary triangulation from the coast over the States has been prosecuted in earnest. This will be of the highest value to the States, since it will give them a uniform and connected frame-work for use in all local surveys. Incidentally to this is begun the measurement of the arc of the 39th parallel nearly 50° long, and of the 99th degree of longitude, which in the United States is 23° long, and which may be extended north and south to a length of 50°. This will furnish two lines of the highest value in solving the great problem of the figure of the earth. The western part of the 39th parallel is admirably situated for using long lines in the primary triangulation. One of those actually observed on is 192 miles long.

Among the appendices should be specially named: a report on the results of the Longitudes of the Coast and Geodetic Survey determined up to the present time by means of the electric telegraph, by Mr. SCHOTT; a report on the blue clay of the Mississippi river, by Dr. LITTLE; a treatise on the plane table, by Mr. HERGESHEIMER; on the determination of time, longitude, latitude and azimuth, by Mr. SCHOTT; report on the currents and temperatures of Bering Sea and the adjacent waters, by Mr. DALL; and an attempt to solve the problem of the first landing place of Columbus in the new world, by Capt. G. V. FOX.

Mr. Schott gives in his four papers on the determination of time, longitude, latitude and azimuth a new edition of papers that had been previously issued, on the use of portable instruments in their various forms as employed in the Survey. To one statement in the third part (p. 245) exception ought to be taken. In speaking of the temporary conversion of the ordinary transit instrument into a zenith telescope by attaching to the former a delicate level and micrometer, Mr. Schott says that Mr. Davidson *first,* and Professor Lyman *subsequently,* made the suggestion and practical illustration of it. Not only this suggestion and its practical illustration, but also its publication by Professor Lyman, preceded those by Mr. Davidson. H. A. N.

2. *Telescopic Meteors.*—In the Observatory for April, Mr. Denning remarks upon the number of telescopic meteors observed in his ten-inch reflector while using comet eye-pieces. He says: "A rough computation from my own somewhat meager results shows that in a space of sky about 50° square (such as may be well commanded by the naked eye) the hourly number of telescopic meteors is about 260, whereas the number of naked-eye meteors averages 12, so that the proportion of telescopic to naked-eye meteors is as 22 to 1." He remarks on the apparent slow motion of the telescopic meteors. He makes the suggestion that observ-

ers engaged in comet sweeping keep a record of the number of telescopic meteors seen and the length of time of observation. Such a record would be of special value, and we trust it will be followed by persons using low-power telescopes.

The time, direction, length of path, velocity, brightness, etc., of such meteors, with diameter of field and magnifying power, would be desirable items in such a record. This would be particularly true for nights of special abundance, like the 10th of August. The area which Mr. Denning names as one that can be commanded by an observer is, we believe, much too great (this Journal, II, xli, 191). On the other hand, it is doubtful whether the whole field of a comet-seeker can be well commanded.

H. A. N.

3. *Gold Medal of the Royal Astronomical Society of London.*—The gold medal of the Astronomical Society has been awarded this year to Dr. B. A. Gould for his Uranometria Argentina.

4. *Medals awarded by the Geological Society of London.*—At the annual general meeting of the Geological Society, held February 16, 1883, the awards by the Council of the various medals were announced. The *Wollaston Gold Medal* was awarded to Mr. W. T. Blanford, "in recognition of services to geology in Abyssinia, in Persia, and on the Geological Survey of the Indian Empire." The balance of the proceeds of the Wollaston Donation Fund was awarded by the Council to Prof. John Milne, of Tokio, Japan, "to mark its appreciation of the importance of his investigations into the phenomena of earthquakes, to which he has devoted so much time and attention during his residence in Japan." The *Murchison Medal* was awarded to Prof. Heinrich Robert Göppert, of Breslau, "in recognition of his labors in fossil botany." The balance of the same fund was given to Mr. John Young, F.G.S., of the Hunterian Museum, Glasgow, "in appreciation of his long-continued researches on the fossil polyzoa, etc." The *Lyell Medal* was presented to Dr. W. B. Carpenter, "in recognition of the great value of his investigations into the minute structure of invertebrate fossils and his deep-sea researches." One-half of the balance of this fund was given to Mr. P. Herbert Carpenter, author of papers on Jurassic Crinoids, Cretaceous Comatulæ, etc.; and the other half to M. E. Rigaux, of Boulogne, author of researches on the Jurassic formations of the Boulonnais and their contained fossils. The *Bigsby Gold Medal* was presented to Dr. Henry Hicks, in "appreciation of his labors among the oldest fossiliferous and the Archæan rocks of Great Britain and Ireland."

5. *The Eastern United States Society of Naturalists.*—At a meeting held in the early part of April, at Springfield, Mass., there was organized "The Society of Naturalists of the Eastern United States," with the following officers: President, Professor A. Hyatt of the Massachusetts Institute of Technology; Vice-presidents, Professor H. Newell Martin of Johns Hopkins University and Professor A. S. Packard, Jr. of Brown; Secretary,

Professor Samuel F. Clarke of Williams; Treasurer, Professor William B. Scott of Princeton; these officers constituting the executive committee. The object of the society is "the association of working naturalists for the discussion of methods of investigation and instruction, laboratory technique and museum administration, and other topics of interest to investigators and teachers of natural history, and for the adoption of such measures as shall tend to the advancement and diffusion of the knowledge of natural history in the community." Membership is limited to instructors in natural history, officers of museums and other scientific institutions, and other persons professionally engaged in some branch of natural history. Meetings are to be held at different places designated by the society, not outside of the Eastern or Middle States, Maryland and the District of Columbia. The annual meeting is to commence on the second Wednesday of March in each year, unless otherwise ordered by the executive committee. Provision is made to encourage the formation and coöperation of similar societies in other parts of the country. The society starts off with a membership of 27, representing the leading institutions in its district, and at the opening meeting, fifteen additional names were proposed for membership.

6. *National Academy of Sciences.*—At the meeting of the National Academy at Washington in April, Professor O. C. MARSH, who, as Vice-President, had been the Acting-President since the decease of Professor WM. B. ROGERS, was elected to fill the office of President. The following persons were elected members of the Academy: A. Graham Bell, Dr. John S. Billings, Professor G. K. Gilbert, Professor H. B. Hill and Professor C. Loring Jackson; and the following Foreign Associates: Adams, Anvers, Berthelot, Bertrand, Boussingault, Calley, Chevreul, Clausius, DeCandolle, Dumas, Helmholtz, Hooker, Huxley, Kirchhoff, Kölliker, Oppolzer, Pasteur, Richthofen, Sylvester, Stokes, Struve, Thomson, Virchow, Wurtz.

On Thursday, the 19th, the Academy participated in the ceremonies connected with the unveiling of the statue of JOSEPH HENRY, under the auspices of the Smithsonian Institution, at which all the departments of the Government were represented. The oration on the occasion was delivered by President Noah Porter of Yale College, one of the Regents of the Smithsonian Institution, and was an admirable tribute to the memory of the eminent physicist. A list of the papers read at the meeting is deferred to another number.

7. *Index to the Popular Science Monthly* for the twenty volumes from 1872 to 1882, and of the three volumes of the supplement. 169 pp. 8vo. New York: 1883. (D. Appleton & Co.)—The publishers of the well-known Popular Science Monthly have done its readers an important service in issuing this convenient Index.

OMISSION.—*Contributions to the Geological Chemistry of Yellowstone National Park.* The analyses on page 351 are by H. LEFFMANN.

THE

AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

ART. XL.—*On the Nature of the Induration in the St. Peters and Potsdam Sandstones, and in certain Archæan Quartzites, in Wisconsin;* by R. D. IRVING.

[Published by authority of the Director of the United States Geological Survey.]

IN his address before the Geological Society of London, delivered Feb. 20th, 1880, Sorby describes sands whose grains are bounded externally by crystalline faces, but have on the interior the ordinary rolled grains, the quartz with crystalline faces having been deposited as a coating on the irregular surfaces of the original grains. He also states that the deposited quartz is in "perfect optical and crystalline continuity" with the interior grains, each broken fragment having been changed to a "definite crystal." He shows, further, that such crystalline sands occur in the sandstones of various ages "from the Oölites down to the Old Red," and that they are commonly little coherent, but that in some specimens "a number of grains may often be seen cohering more strongly than the rest; and these show clearly that the cavities originally existing between the grains have been more or less completely filled with quartz. Moreover, on carefully examining the less coherent grains by surface-illumination, we can see, not only the planes and angles due to unimpeded crystallization, but also more or less deep impressions due to the interference of contiguous grains, thus proving conclusively that the deposition of crystalline quartz took place after the nuclei were deposited as a bed of normal

sand. The very imperfect consolidation sometimes met with is, perhaps, not so very surprising, when we reflect on the very small coherence of many large quartz crystals which are yet in close juxtaposition. However, it does seem probable that this crystallization of quartz sometimes contributes very materially to the cohesion of the grains in hard and compact quartzites. In such examples as the Gannister of the South Yorkshire coal-field we can see, in a thin section, that the grains fit alongside one another in a very striking manner, and it is only by extreme care that good proof can be obtained of the actual deposition of quartz between them. However, in the case of a highly consolidated sandstone from Trinidad, the proof of the deposition of quartz is as complete as possible; the outline of the original grains of sand is perfectly distinct, and the cavities between them are filled with clear quartz in crystalline continuity with the contiguous grains, so that the whole is a mass of interfering crystals, each having a sand-grain as a nucleus. The rock has thus been converted into a hard quartzite, almost like a true quartz rock, but differs from such quartz rocks as those of the Scotch Highlands in containing no mica crystallized *in situ.* All my specimens of these quartz rocks are really highly quartzose mica-schists; and, so far, I have failed in my endeavors to trace the connection between them and true sandstones, though possibly this could easily be done in some districts which I have not examined."

These very highly interesting and important observations of Sorby have received surprisingly little attention, and I had missed them altogether, so that it was not until after I had reached the conclusions and made most of the observations referred to in this paper, that I learned that he had preceded me by over two years in some of the most important points. I am able, however, to extend his conclusions in some important respects. What he regards as probable, viz: that the "cohesion of the grains in hard and compact quartzites" is due to this deposition of interstitial quartz, I find certainly true. But more than this, I find in certain Archæan quartzites, and presumably the same thing is true of many more, that the "metamorphism" has consisted entirely in this deposition of interstitial quartz. Still further, I find that these same quartzites grade directly into true mica-bearing quartz-schists, where the only change besides the formation of interstitial quartz has been the development of mica scales from intermingled kaolinic material in the original rock. I may, therefore, with propriety publish a brief account of my observations and conclusions.

In beginning recently a systematic microscopic study of the crystalline schists of the northwestern states, I selected the quartzites as likely to yield the most readily, to this sort of

investigation, evidence of the nature of the metamorphism involved in their formation. The frequent gradation of the most compact, non-granular, often vitreous quartzites into plainly arenaceous and even pebbly, water-deposited rocks, and the small number of minerals and consequent probable simplicity of any chemical reactions involved, encouraged me to hope that I might find some clue to the solution of the problem of their metamorphism. I had already been led by many considerations to suspect that the change which the original sandstones had undergone in becoming quartzites was rather in the nature of an interstitial deposition of quartz from impregnating siliceous waters, than of a re-crystallization, or molecular re-arrangement of the original quartz grains. Among the things that tended to confirm me in this suspicion was the fact that in the Potsdam sandstone of Central Wisconsin, which is for the most part a loose and even incoherent sandstone, made up of rolled quartz grains, I had in my work for the Wisconsin State Survey frequently observed portions which were more or less indurated, and plainly by quartz, there being no other indurated substance present. These indurated portions are sometimes irregular areas and again are confined to certain layers intercalated in the usual incoherent material. In general, the formation is more indurated in its lower portions. The amount of induration varies greatly, in some cases being a barely perceptible hardening, and again ranging through various degrees to an extreme in which the rock becomes a compact almost vitreous quartzite, the thin slabs ringing like steel when struck with a hammer. Now it is certain that in such an unaltered, nearly horizontal and wholly undisturbed formation as this sandstone is, these indurations can not be in the nature of the ordinary orthodox regional metamorphism through which the crystalline schists are generally believed to have passed. Moreover, I had often observed a peculiar hardening and vitrification of both this sandstone and that of the St. Peters, on exposed surfaces, which is plainly a result of weathering and therefore of a necessity wholly unlike such a thing as a general re-crystallization. This peculiar effect of weathering, which I have never until within a few weeks seen noticed in any publication,* presents itself generally in the shape of a thin shell, usually from a fraction of an inch to an inch in thickness, of lustrous, vitreous, watery-looking quartz. It is found also proceeding inwards from the sides of joint cracks; and where the

* In Geikie's Text Book of Geology, pp. 158, 333, the exposed blocks of Eocene sandstone which are known as "grey wethers" in Wiltshire, and which occur again in the region of the Ardennes in France, are spoken of as becoming, under meteoric influences, a kind of lustrous quartzite.

rock is much jointed and exposed, the induration has sometimes extended in for some distance.*

In preparing my first material for the study of the quartzites, I selected the Huronian quartzites of the Baraboo Ranges of Sauk Co., Wisconsin, and, for comparison, the various vitrified and indurated forms of the Potsdam and St. Peter's sandstones above alluded to. Beginning first with the Baraboo quartzites I noticed at once in many sections, as viewed in ordinary light, a distinct clastic structure, rounded grains of quartz, outlined often by a little film of iron oxide, making up most of the section, but with a clear quartz in the interstices. Often some of the quartz grains would seem ill-defined, and look as though they melted away into the interstitial quartz; an appearance which has been noted by other observers in sections of the quartz-rocks of various regions.† In polarized light, however, it was often observed that all appearance of a clastic nature would disappear, instead of being more prominently brought out, as in an ordinary sandstone. In place of the rounded grains seen in the ordinary light, would now be seen only a mass of interlocking quartz areas, presenting every appearance of having crystallized in their present positions. Close study showed that the larger part of the quartz, that appeared in the ordinary light to be interstitial, *polarized with the rounded grains*, i. e., the individual quartzes extended beyond the limits of the grains. If the apparently fragmental particles were truly so, this appearance could only be explained by a deposition of quartz in such a way as to have crystalline continuity with the original grains.

That the force of crystallization was able to finish a crystal, or to restore a broken crystal, after the lapse of many ages, was to me a new conception, and one which seemed to call for very rigid demonstration before acceptance. There was little difficulty in proving that the apparently fragmental quartzes

* As an instance of a completely vitrified layer in the Potsdam of Wisconsin, may be mentioned the fossiliferous rock of Silver Bluff in the Trempealeau Valley, Jackson Co. (Geology of Wisconsin, ii, p. 566); as instances of a less completely indurated rock, that of the quarry at Black River Falls depot, Jackson Co. (Geol. of Wis., ii, p. 566), that of the quarry near Grand Rapids, Wood Co. (Id., p. 564), that of the quarry near Stevens Point, Portage Co. (Id., p. 564), and that of the quarry at Packwaukee, Marquette Co. (Id., p. 579); and as instances of the quartzite-like weathering in the Potsdam, that of the Roche Écrit Bluff near Friendship, Adams Co. (Id., p. 573), and of Petenwell Peak on the Wisconsin River, Juneau Co. (Id., p. 572). St. Peters sandstone with a vitrified crust may be best seen on the bold cliff known as Gibraltar Bluff on the south side of the Wisconsin River in Columbia Co. (Id., p. 589). and in the isolated knob on top of the Arlington prairie, Columbia Co. (Id., p. 585). It should be said that at the time these places were described for the Geology of Wisconsin (1876), the writer had barely begun his acquaintance with microscopic lithology, whence it comes that these rocks have never been studied microscopically until now.

† A. Geikie, Text Book of Geology, p. 127.

were indisputably of that nature, while the proof that such a thing is possible as the deposition of quartz upon a quartz surface, in such a manner as to be crystallographically continuous with it, was also forthcoming. At this stage of the investigation I called to mind the description of rounded quartz grains enveloped in quartz crystals, given by the Rev. A. A. Young in this Journal for July, 1882. Mr. Young had long before sent me specimens of the sand showing this peculiarity, but the time had not served for their study. Mounting some of them now in balsam, a moment's study with the microscope sufficed to show—what Mr. Young had not spoken of in his paper referred to—that the enveloping water-clear quartz, furnished with crystal faces, was optically oriented with the enclosed rough-surfaced, rolled grains. In the loose New Lisbon sandstone, then, the new quartz found room to develop crystalline faces, because of the small supply of silica, while in the Baraboo quartzites the supply of siliceous material was so large as to cause universal interference and irregularly outlined areas, whence the non-clastic appearance in polarized light, and the occasional non-clastic appearance in the ordinary light when no iron oxide or rough surface was present to separate new and original quartz.

Proceeding now to an examination of the remainder of my material, I soon found, as I had by this time anticipated, that the induration was of the same nature throughout—in St. Peter's and Potsdam sandstones, as well as in the Archæan quartzites—and, indeed, that my sections showed a completely graded series from loose sandstone, in which the rolled grains were enveloped in crystals of deposited quartz, to the most compact and apparently non-granular quartzites, and even to highly schistose quartzites with a clayey admixture in which mica flakes had developed.

I may now describe briefly a series of specimens illustrating these different degrees of alteration, beginning with the least indurated.

The first specimen is of the Potsdam sandstone from the quarries at New Lisbon, Wis.—the same as described by Mr. A. A. Young in this Journal for July, 1881. It is a very fine-grained, pink- and white-mottled sandstone, from which the light is reflected in numerous sparkling points. The induration is distinct, but only slight, small fragments crumbling readily in the fingers. The crumbled sand, mounted in balsam, shows every grain edged with more or less of the deposited quartz, which is always optically continuous with the original grain. The line of junction between the new quartz and the old is always strongly marked, either by a contrast between

the cloudiness and worn surface of the original grain and the pellucidity of the deposited quartz, or by the presence upon the surface of the original grain of a coating of oxide of iron. Only the smallest of the grains seem to show perfect crystalline faces, the supply of new quartz having been so great as to produce some interference in most cases. This is indicated by the indentations observable in the crystalline outlines, as shown in figs. 1, 2 and 3, which represent grains of this sand as seen

1. 2. 3.

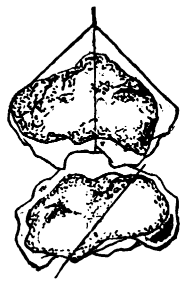
mounted in balsam. In this mounting the crystalline faces on the upper sides of the grains are not readily seen, but only the rough surfaces of the original grains, and the crystal outlines of the deposited quartz. The interference has, however, never extended very far, every grain showing some traces at least of the crystalline faces when viewed in a dry mounting. Evidently the small amount of induration in this sandstone is to be connected with this relatively slight amount of interference. As shown by Sorby,* the most perfect crystalline outlines are to be met with in quite unconsolidated sands, the quartz having then had full opportunity to develop perfect faces. In the figures drawn from the mountings of this sand, I have placed the three grains with their elasticity axes in a common direction.

The second specimen on the list is from the Potsdam sandstone of the quarry at the depot at Black River Falls, Wisconsin. It is a white, much coarser-grained, and perceptibly more indurated rock, than the last, but many crystalline facets of some size are perceptible. The cause of the greater induration becomes readily apparent when the balsam mounting of crumbled grains is examined. Every grain is coated with the deposited quartz, and usually has a broader border than seen in the grains of the New Lisbon rock. Only here and there are to be seen traces of distinct crystalline outlines, many grains showing no linear boundaries at all, while no single grain is without evidence of the interference of its deposited quartz with that of some contiguous grain. In fig. 4, two of the

* Op. cit., p. 37.

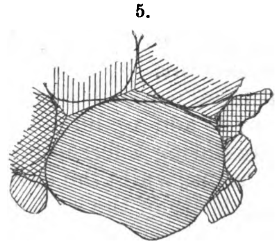
grains of this rock are shown in contact, the line drawn on each indicating the position of its elasticity axis. On the upper side of the upper one of the two grains the pyramidal outline is apparent, but below the deposited quartz of this grain interferes with that of the next one, upon which no linear outlines whatever are visible, the interference with the deposited quartz of contiguous grains having evidently been complete.

4.

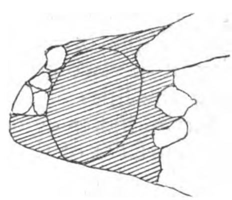


The next specimen is one from an outlier of St. Peters sandstone, in the town of Arlington, Columbia Co., Wis. The larger part of the specimen shows a fine-grained, very loose, saccharoidal sandstone, in which there is almost no trace of induration, but in which numerous flashing points indicate the presence of crystal coatings to the grains. About one-fourth of an inch, however, on the weathered side of the specimen, presents the appearance of a completely vitreous quartzite. Seen under the microscope a thin section of this vitrified crust shows plainly the original rounded grains of the sandstone, but everywhere between them a deposited quartz which is divided off into areas coördinating optically with the original grains. The interference between the different areas of this deposited quartz has been nearly always too great to allow of the formation of crystalline outlines. Figs. 5 and 6 represent portions of the section of this crust. The smooth curved lines of the figures show the outlines of the original grains, while the shading indicates the way in which the original and deposited quartz polarize together.

5.



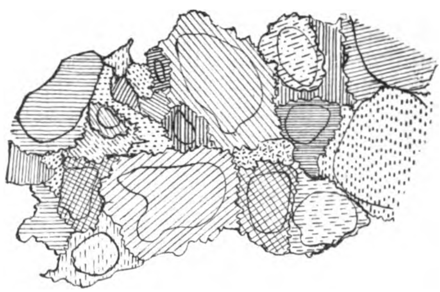
6.



The next specimen is one of St. Peter's sandstone from Gibraltar Bluff, a very bold and prominent point on the south side of the Wisconsin River in the town of West Point, Columbia Co., Wis. This rock is one which, if found among the crystalline schists, would undoubtedly be classed as a quartzite. It is a very much indurated, light-colored rock, in which a very fine arenaceous texture is perceptible only on the closest inspection. The thin section of this rock in polarized light shows

only interlocking grains of quartz. These interlocking grains are of two very different sizes, the larger ones predominating while the smaller here and there fill up spaces between the larger. Close study of this section in ordinary light brings out the fact that each of the larger ones of these areas, and here and there one of the smaller ones, is made up of a rounded, smoothly outlined worn grain, and a border of deposited quartz, the border and the worn grain within polarizing together. The outlines of the bordering quartz are exceedingly irregular, the different areas interlocking with one another more or less intricately. I have attempted to represent a portion of this section

7.



diagrammatically in fig. 7, the smoothly outlined areas of this figure representing as before the original worn grains and the different shading indicating the areas that are optically continuous. The lines marking the junction of the original grains with the deposited quartz are marked sometimes by a difference in the purity of the two quartzes, but more especially by the presence along the lines of flakes of ferrite and of numerous cavities, the ferrite flakes evidently representing a ferruginous coating on the surfaces of the original grains, while the cavities are plainly produced by the great irregularity of the surfaces upon which the new quartz was deposited. Some of the smaller areas of interstitial quartz above alluded to may have been wholly produced by deposition, the infiltrated quartz in this case not coördinating itself with original grains. It would evidently be difficult, however, to prove this to be the case, since the outlines of the original grains are now perceptible only when they were well coated with iron oxide or were rough enough to produce cavities in the deposited material.

The next specimen is from the Archæan quartzite of Devil's Lake, Wis. As I have indicated elsewhere* the larger portion of the quartzite of this region is without arenaceous appearance, being usually of a non-granular, flakey texture, and of a color

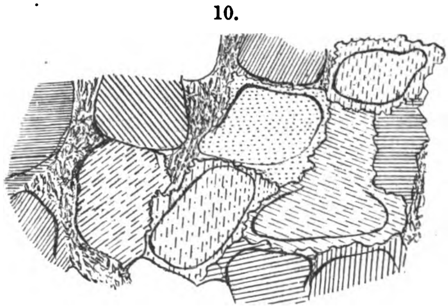
* Geology of Wisconsin, vol. ii, p. 505.

from nearly white, through gray, pink and purple to purplish-red, and even brick-red. Now and then a tendency to an arenaceous texture is observable, and occasionally small areas are little more than moderately indurated sandstone. It is from one of these least indurated portions that the present specimen is taken. The rock is only a little more indurated than that above described as from the Potsdam of Black River Falls. The sand broken from this specimen and mounted in balsam is seen to be precisely like that of the Black River Falls rock, except that the interference has been too great to allow the formation of any crystalline outlines in the deposited quartz. The rock is, however, much further from a true quartzite than either of those above described from the St. Peter's sandstone. Figures 8 and 9 represent grains broken from this rock.

8. 9.

The sandstone thus described grades immediately into a more indurated rock. A specimen taken a few inches rom it shows a rock much like that of the St. Peter's at Gibraltar Bluff, both as to texture and amount of induration; and this resemblance is borne out by the appearance of the thin section, which shows—as does also that of the Gibraltar rock—rounded grains surrounded by closely interlocking areas of deposited quartz coördinated optically with the original grains. The only distinction of importance between this rock and that of Gibraltar Bluff is the presence in it, here and there, of an interstitial kaolinic material, made up of minute brilliantly polarizing flakes of kaolinite. Figure 10 is drawn from the thin section

10.



of this rock, the smooth curving lines as before, indicating the outlines of original grains, and the zigzag lines, the intersections of different areas of deposited quartz; while the shadings indicate the manner in which the new quartz polarizes with the old.

Within a few inches from the point at which the specimen

last described was taken, the rock has become hard, vitreous, purple quartzite, without trace of arenaceous appearance; in other words the ordinary quartzite of the region. The thin section of this rock, in polarized light, shows no trace whatever of a fragmental origin, the grains being completely interlocked, but in ordinary light, here and there, may be distinctly seen the rounded outlines of an original grain, polarizing with the deposited quartz surrounding it. As in the Gibraltar rock, so also in this section, there is much of a fine interlocking interstitial quartz which may have been in part or wholly deposited.

A step beyond the last specimen described is shown by another from a point farther east, on the same quartzite range in the town of Caledonia, Columbia Co., Wis. Microscopically this specimen shows numerous large quartz fragments embedded in a finer non-granular matrix, which is distinctly schistose, being apparently a clayey quartzite. At first sight the thin section of this rock seems to show no trace of fragmental origin, being made up of relatively large quartz particles embedded in a matrix composed of finer angular quartz particles and much of a kaolinic material. The quartz grains show throughout a tendency to have their longer axes in a common direction. Occasionally in the finer matrix are developed small but distinct muscovite scales. Close study of the section brings out here and there the same feature as heretofore noted, namely, the presence in the interlocking angular quartzes of cores composed of rounded grains. The section of this rock is indistinguishable from a number that I have examined of the argillaceous quartzites of the Lake Superior Huronian.

It thus appears that the alteration which has produced from sandstone certain Archæan quartzites and quartz-schists is of the same nature as the induration which affects—quite independently of any igneous action—irregular areas in wholly undisturbed and elsewhere wholly unaltered sandstones, and even as the surface induration produced in some sandstones by mere weathering. All of these changes are due to the deposition of interstitial quartz in such a manner as to be crystallographically continuous with the original clastic particles.

The origin of the saturating quartz is a point of great interest. In the case of the indurated crust it seems evident that the deposited silica has accumulated at the surface by evaporation and capillary action on a relatively minute quantity of a siliceous solution permeating the rock. The only probable origin for the silica in this solution seems to be in the action of the atmospheric waters upon occasional feldspar particles in the sandstone. A similar origin may be assigned for the silica of

most of the indurated rock of the St. Peter's and Potsdam sandstones; but in some cases there are indications that the induration has followed lines of faulting, where the silica may be extraneous.* In the case of the Archæan quartzites of the Baraboo region an extraneous source is suggested by the frequent occurrence in these quartzites of strings and veins of white quartz, often supplied with cavities lined with quartz crystals.

University of Wisconsin, Madison, Wisconsin, February, 1883.

Art. XLI.—*On the existence of a deposit in Northeastern Montana and Northwestern Dakota that is possibly equivalent with the Green River Group;* by Charles A. White.

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The great fresh-water Eocene series of strata known as the Green River Group occupies, as is well known, a very large region in Southwestern Wyoming and the adjacent parts of Utah and Colorado; but in the absence of positive evidence it may well be doubted whether the strata of that group ever extended much if any to the northward of the 43d parallel of latitude. Last summer while studying the Laramie Group, in the region of the Lower Yellowstone River, I found a small deposit lying nearly upon the 47th parallel of latitude which, in consequence of its stratigraphical relations, its lithological character, and the fact that it contains small Teliost fishes, is strongly suggestive of identity with the Green River Group. The deposit is only a few acres in extent, and lies upon the top of an elevation known as Sentinel Butte, two or three miles east of the boundary line between Dakota and Montana, three or four miles south of the Northern Pacific Railway, and about fifty miles east of the point where that railway reaches the Yellowstone Valley.

The whole region between the Yellowstone and Missouri Rivers, north of the parallel of 46°, as well as much of the Upper Missouri River country adjacent to this region, is occupied by the Laramie Group, which at few and distant intervals in the valleys of those rivers is seen to rest conformably upon the Fox Hills Cretaceous group.

The strata in this whole region are approximately level except in a few localities where limited flexures occur. The geology of the region is therefore exceedingly simple. The Lara-

* See T. C. Chamberlin's description of the formation at Ironton, Wis., Geol. of Wis., vol. iv.

mie Group I estimate at about 500 feet maximum thickness in that region, but it has everywhere suffered such extensive erosion that I am not satisfied that I have seen its uppermost layers at any point except at Sentinel Butte, and one other similar butte forty-five miles to the northwestward of it.

Sentinel Butte lies between the Little Missouri, a tributary of the Great Missouri River on the east, and Beaver Creek, a tributary of the former, on the west. Along the divide between these two small streams there are numerous buttes composed of the material which has escaped the great and general denudation that the region has suffered, and which constitute the principal features of the landscape. The strata of which these buttes are composed are approximately horizontal, and the fact is apparent at a glance that the intervening lower lands have been made such by erosion. While the surface of this region is more completely grass-covered than that of the region directly southward on the Great Plains, the exposure of the strata which underlie the surface here is general, and their order of superposition is easily traced.

The Laramie Group within the region in question is made up of variously colored sandy shales and Bad-land sandstones, with numerous beds of lignite and carbonaceous material. In many places the beds of lignite have been burned out, giving a conspicuous brick-red color to the strata thus affected. From its junction with the Fox Hills Group in the Yellowstone Valley, the strata of the Laramie Group were traced out into the country upon either side, and up into the higher lands, including the buttes before mentioned; of which Sentinel may be taken as an example.

This butte rises about three hundred feet above the general level of the land around it, and the characteristic strata of the Laramie Group, including its lignite, are readily traced to within one hundred feet of the flat, nearly level top. Resting conformably upon these Laramie strata we find about sixty feet in thickness of coarse sandstone strata, the lower half being more thinly and evenly stratified than the upper. This sandstone presents a precipitous front at almost all sides of the irregularly shaped butte, to which it gives the appearance of a massive cap in the distance.

Resting directly and conformably upon this sandstone is a mass of light gray fissile calcareous shales which, to one familiar with the aspect of the typical shales of the Green River Group, at once suggests their identity. These shales are plainly a remnant that has escaped erosion, and were found to occupy an area at the top of the butte estimated at forty acres, and their maximum thickness at forty feet. The presence of the coarse sandstone was detected at the top of a few others of the higher

buttes in this region, but the fissile shales were found only on Sentinel Butte. It is probable, however, that they will be found at the top of other buttes in that region.

Searching these shales I found the two species of fishes which are described in following paragraphs by Professor Cope, but no other traces of fossils of any kind were discovered in them. It will be seen from Professor Cope's remarks that these fishes are not closely related to any hitherto described, and they are therefore not of service in directly identifying the strata from which they come with the Green River Group or with any other. They are, however, of such a character that they may have lived in such lacustrine waters as the Green River Group was deposited in.

In the absence of paleontological evidence we must rely upon the stratigraphical relations of this deposit in considering its claim to be regarded as a part of the Green River Group. I am by no means confident that this small deposit is a part of that group, and once continuous with the same to the southwestward; or that it is in any sense equivalent with the same; but the following facts are worth considering in that connection.

(1.) This small fish-bearing deposit follows in regular order, and rests conformably upon certain sandstone strata, which in turn rest conformably upon typical Laramie strata. The Green River Group at its typical localities in like manner rests conformably upon the Wahsatch Group which in turn rests (in many places at least) conformably upon the Laramie Group.

(2.) The lithological characteristics of this fish-bearing deposit are surprisingly like the fish-bearing layers of the Green River Group.

(3.) Although the fishes of this deposit are not identical with any known forms in the Green River Group, their characteristics are such that no reason is apparent why they may not have lived at the same time and in similar, if not the same, waters as those that have been discovered in that group.

(4.) Their nearest affinities are with fishes that have been found in the Green River Group, and none like them have ever been found in the Laramie Group.

It may be objected that in the Green River region the great Wahsatch Group exists between the Green River and Laramie Groups; and that it has not been shown to be present in connection with the small fish-bearing deposit in question. In reply it may be remarked that although so thin, the coarse sandstones between this small fish-bearing deposit and the Laramie strata on Sentinel Butte may be reasonably supposed to represent both the Lower Green River Group of Powell and the Wahsatch Group of Hayden. Indeed it seems plausible that

whether the typical strata of either the Green River or Wahsatch Groups were ever continuous with these northern strata or not, we have in that upper one hundred feet of Sentinel Butte the chronological representatives of the Upper and Lower Green River and the Wahsatch Groups combined. Whatever the facts of the equivalency of the strata here discussed may be, I have no doubt that the small fish-bearing deposit in question was laid down in waters that immediately succeeded the close of the Laramie Group, and that it is not properly a part of the same although it rests with apparent conformity upon it.

The following is Professor Cope's description of the fishes referred to in the foregoing remarks:

On a new extinct genus and species of Percidæ from Dakota Territory; by E. D. Cope.

The specimens of fishes submitted to me by Professor C. A. White represent four individuals and two species. These belong apparently to the Centrarchine division of the Percidæ, and although the future discovery of the structure of the ventral fins may invalidate this conclusion I do not anticipate such a result. I am also unable to determine whether there are teeth on the vomer or not. As regards generic affinity the species do not enter any of the genera now known from American or European Tertiary formations, as will be seen from the characteristics about to be given. They differ from those of the recent genera of Centrarchinæ, in the entire, circular outline of the operculum; and from some of them in the anal fin with five spinous rays originating posterior to the line of the anterior border of the spinous dorsal fin. This new genus I name *Plioplarchus*, and give the following diagnosis. Family characters, etc.: Mouth bounded above by premaxillary bone only. Branchiostegal rays seven, possibly eight. Ventral fin commencing below the base of the pectoral. Scales ctenoid.

Generic characters: Teeth few, simple and conic. No indication of large pharyngeal bones. Preoperculum entire posteriorly and at the angle; inferior edge unknown. Operculum rounded, entire. One dorsal fin. Anal fin commencing below the middle of the spinous dorsal; with five or more spinous radii. Caudal fin openly emarginate. Lateral line continuous, uninterrupted.

The species may be described as follows:—

Plioplarchus Whitei Cope.

General form elongate oval, the dorsal and ventral outlines of the body about equally convex. The length of the head enters that of the head and body to the extremity of the caudal

vertebræ, three times; and the depth of the body at the ventral fins enters the same two and two-thirds times. The muzzle is short and obtuse, and the mouth opens obliquely upward. The orbit is very large, and enters the length of the head to the border of the operculum three times, and is one-third of itself longer than the muzzle.

The radial formula is: D. IX–12; C+17+; A.V–14; V.?; P. 13. All the soft rays are fissured distally. The dorsal spines increase in length to the last one, as do also the anals. The pectoral rays reach to below the sixth dorsal spine, and beyond the extremity of the ventral fin, which does not quite reach the anal. The soft rays of the anal extend to a point below the extremity of the vertebral column, forming a well-developed fin. The extremity of the soft dorsal is lost. The external rays of the caudal fin are a little longer than the median. The spine of the ventral fin is not strong. The caudal peduncle is moderately narrow. The vertebral column is convex upward anteriorly: no., caudal XVI; abdominal XII to the edge of the operculum. A caudal vertebra preserved in place has two lateral fossæ separated by a horizontal keel. The abdominal cavity extends posterior to the anterior spinous rays of the anal fin, so that the anterior interhæmals are directed upward and backward. The ribs are long. There are four interneural bones anterior to the dorsal fin. The postcoracoid is elongate.

There are seven or eight longitudinal rows of scales visible above the vertebral column, and sixteen below it; the size diminishing rapidly downward. All the bones of the head excepting the muzzle and jaws are covered with scales. There are six rows on the cheek below the eye. The scales of the body have the basal radial grooves and ridges few and coarse. The external surface is finely but strongly rugose with tubercles or grains, with a trace of fine concentric lines across the superior and inferior edges. Marginal denticles small. The interior faces of the scales which cover part of the fossil display numerous very close and fine concentric lines, with a small triangular rough area extending from the edge toward the center.

Measurements:

Total length, with caudal fin	.116^{m}
Depth at front of dorsal fin	·033
Length of caudal fin to base of vertebra	·0247
Length of caudal vertebra	·0365
Length of base of dorsal fin	·0325
Length of base of soft dorsal	·015
Length of seventh dorsal spine	·017
Length of third dorsal ray	·020

Length of fifth anal spine	·0165
Length of fourth anal ray	·022
Length of base of anal fin	·0245
Length of pectoral fin	·020
Length of ventral fin	·017
Depth of caudal peduncle	·012
Depth of head at orbit, posteriorly	·026

The typical specimen of this fish is in excellent preservation. The species is dedicated to Dr. C. A. White, the distinguished geologist and paleontologist.

Plioplarchus sexspinosus Cope.

This species is represented by two specimens, both of which lack the head and body anterior to the dorsal fin. One of the specimens is accompanied by its reverse. The differences between this species and *P. Whitei* are to be seen in the radial formula. This shows more numerous spinous, and less numerous cartilaginous, rays. The formula is: D X−13; C+17+; A. VI−9. The last anal radii are somewhat injured, and these may have been more than nine, but no trace of others exist and it is clear that they were less numerous than in *P. Whitei.* There are about eighteen series of scales below the vertebral column at the front of the dorsal fin. Their external surfaces are not so rough as in *P. Whitei*, as the granules are confined to the center of the scale, and in the concentric lines are much more obvious, and form a wider border. Ctenoid denticles distinct. Caudal fin openly emarginate.

Measurements:

Depth at anterior edge of anal fin	·0206^{m}
Length from do. to the end of the caudal vertebræ	·0305
Length of caudal fin to vertebral centra	·020
Length of base of dorsal fin	·0282
Length of base of soft dorsal	·015
Length of base of anal	·017
Length of base of spinous anal	·008
Length of ninth dorsal spine	·013
Length of fifth anal spine	·015
Depth of caudal peduncle, about	·011

Remarks:—

Among the known extinct types of fishes it is *Mioplosus* Cope that approaches nearest this one. The former is characteristic of the Green River beds of the Lower Eocene. The genus *Plioplarchus* does not enable me to identify the horizon from which it is derived with any of our known formations. It only permits the general statement that its age may be Tertiary or Upper Cretaceous.

ART. XLII.—*On the Peculiar Concretions occurring in Meteoric Irons;* by J. LAWRENCE SMITH, Louisville, Ky.

FOR some time after meteorites, either stony or iron, became special objects of interest, little attention, comparatively, was given to their chemical and mineralogical constitution, and it is not much over forty years that good and reliable information on these points has been furnished. Much of the work that has been done deserves to be repeated by our improved methods as regards both their mineralogy and chemical constitution. This study is necessary in order to guide us in the future to some correct view of their lithological position in the universe.

My object at the present time is to refer to one point, in connection with the structure of the irons, that has occupied more or less critical study on my part since 1851, the results having been published from time to time without my attempting to generalize them. Reference is here made to the concretions in the interior of meteoric irons, the larger and more important ones being of a nodular character, or more or less globular.

In some of these irons no visible concretions have been developed by the sections of them that have been thus far made. Notably among this class is the Dickson County iron, that was seen to fall in 1835. Whether this would hold good, if many more sections of it were made, we cannot tell. I have not seen them in any sections of the Braunau iron, which was also seen to fall, but my observations on this last iron have been limited. There are other meteorites of which the time of fall is not known that can be placed in the same category. But the presence of concretions is the general rule.

What are these concretions? Those which first attracted attention, on account of their size and constancy, were composed essentially of sulphur and iron, so well and widely known in the Seelasgen iron, sections of which were early and largely distributed among mineral cabinets.

The second kind of concretion noted is of a brighter yellow color than the last, with which it was long confounded, until Partsch pointed out that it consisted essentially of phosphorus and iron; it is seen in a very marked manner in the Lockport, Toluca, Tazewell and many other irons.

A third concretion, of a dull black color, frequently more or less mixed with the sulphuret, was found to be a form of graphite, as in the Sevier and Toluca irons.

A fourth concretion, found by me in two different irons, was in small parcels and consisted of protochloride of iron.

A fifth concretion I discovered in 1876 in the Cohahuila masses, called the Butcher meteorites. It is second to none in interest, having marked mineralogical and chemical characteristics to be referred to under its proper head, it being a sulphuret of chromium and iron.

A sixth concretion is one I have but recently discovered. I have as yet found but one specimen, but that of some size and well marked. The specimen is in a polished slab of about twelve inches square, which is now in the hands of Professors DesCloizeaux and Daubrée for inspection, and for the present in the cabinet of the Garden of Plants. It is chromite. The list of concretionary minerals does not terminate here, for there are others of obscure character in the interior of some of those already mentioned, which will be referred to as we make a short statement respecting their manner of occurrence and composition.

Sulphuret of Iron (Troilite, FeS).—The nodules of this mineral are larger than those of any of the others yet found in the interior of meteoric iron, some of them weighing from 100 to 200 grams. As in the Toluca and Augusta County irons, they are most commonly globular, and they are often very numerous in the iron. It is not my object to enter into any detailed mineralogical description of them, for they are well known by their dark bronze color, which color in troilite of the pure type extends unaltered to the very boundary of the enclosing iron. They are either granular in structure, or more solid with a marked cleavage in one direction; the latter kind I have found to be the purest form. It is readily acted on by dilute chlorhydric acid, especially when slightly warmed, and is completely dissolved, thus distinguishing it in a marked manner from some of the other concretions to be referred to. It was for some time considered identical with the magnetic sulphuret of iron (pyrrhotite); but my labors in 1853* proved it to be a protosulphuret of iron (FeS); and further examinations with the purest specimens have confirmed the first results. Rammelsberg and others have, by independent analyses, sustained this determination. Troilite is hence a meteoric mineral having no terrestrial representative.

The iron immediately enclosing these nodules, and within a milligram or two of them, gives but a trace of sulphur on analysis. The finest type of pure troilite I found is in the Sevier County iron, although this iron contains nodules of it largely mixed with other minerals.

Schreibersite (Phosphuret of iron and nickel (Ni_2Fe_4P).—We do not have to go far in the examination of troilite nodules before finding some of them coated or penetrated by a bright

* This Journal, vol. xix.

yellow mineral, quite like some sulphurets of iron but unlike troilite. It is also found in fissures and small irregular cavities, but I have not yet seen it in independent globular concretions. While all forms of schreibersite are interesting, what most attracts the attention of the geologist and mineralogist is its association with troilite, as in the irons of Lockport, Toluca, Tazewell County, Pittsburg, etc. The nodules of troilite in these irons are completely coated with it, the line of demarcation being well-defined. In a section of the Lockport iron that is in my cabinet several nodules of troilite 2^{cm} in diameter have the coating from 1 to 2^{mm} in thickness. On bringing a magnet near to the smaller fragments it is attracted almost as readily as iron, while troilite is barely affected by the magnet. Sulphur is not found in this mineral, although so closely adherent to a sulphuret; and the inclosed troilite contains only a trace of phosphorus although there are 14 per cent in the schreibersite. Its composition and formula as made out by me in 1853* is: Phosphorus 15·47, iron 55·36, nickel 29·17, corresponding to Ni_2Fe_4P. My examinations of other specimens obtained from other meteorites, some in very minute crystals, have proved all to have the same composition. This fact is mentioned because some have supposed that there is another similar phosphuret differing in composition from the above. As yet I have no chemical evidence of this.

The insolubility of schreibersite in chlorhydric acid facilitates the obtaining of it in a pure state, as by this means the last traces of adhering troilite are detached. By means of this reaction, aided by its magnetic property, I have obtained all the pure schreibersite needed for investigation. There has not yet been found any terrestrial mineral like schreibersite.

Graphite.—The next concretion that is most conspicuous in certain meteoric irons, although it cannot be called common, is of the character of graphite. That it is a true graphite is placed beyond all doubt, first by the experiments of M. Berthelot,† who formed graphitic oxide with the material obtained from the Cranberry iron, and by my own experiments made upon graphite from the same iron, and also from other irons, as the Sevier County and the Toluca.

The largest nodule of graphite that has been seen in any meteorite is the one described first by Troost, afterward by myself, which came from the Sevier County iron, and weighed originally 92 grams;‡ a section taken from it in the direction of the longest diameter is now in the cabinet at the Garden of Plants. Most frequently the graphite present is largely mixed

* This Journal, vol. xix, p. 151.
† Annales de Chem. et de Phys., iv–xix, 392, 1870, and xxx, 419, 1873.
‡ Researches in solid carbon compounds in meteorites. This Journal, May and June, 1876. Ann. de Chem. et de Phys., 1876.

with troilite. It is never crystalline in structure like that in the interior of cast iron; it is quite like the graphite of Cumberland, England. On treatment by ether or petroleum spirits, a minute quantity of a crystalline substance is dissolved, that will be referred to later on as mixed with sulphur.

Daubréelite.—This is one of the most interesting concretionary products in meteoric iron. I discovered it in 1875, in the Butcher meteorites; and since then I have found it in other meteorites, but so finely divided and mixed through troilite nodules that it would have escaped notice altogether had it not been for its very marked and prominent mode of occurrence in the above mentioned meteorites.

Being easily separated from the iron, I was enabled to study its properties thoroughly, and thereby furnish a process by which it could be detected in other meteorites when completely obscured from the eye.

This mineral occurs in the Butcher meteorites in the manner already fully described.* It is commonly associated with troilite; but the lines of demarcation are so distinct that particles of the pure mineral are mechanically detached without difficulty. Its composition is now well known to be $FeS + \text{Cr}S_3$, being analogous to terrestrial chromite, with the oxygen of the latter replaced by sulphur. There is no terrestrial mineral of the same composition.† Full details of its mineral characteristics, chemical composition, etc., are found in a previous publication.

Chromite.—The most recently discovered concretion is that described by me as found in a section of the Butcher meteoric iron. This unique specimen consists of an entire nodule, 12×17^{mm}, of nearly pure chromite; and being an oxygen-bearing mineral, it is of special interest in this connection. It is contained in a section of the iron about twelve inches square, which is at present in the Mineralogical Museum of the Garden of Plants at Paris.‡ In mass it is perfectly black; in small fragments under the microscope it is translucent and of a dark ruby color. This translucence of chromite was first noticed a few years ago by an assistant of M. Fouqué of the College of France.

Lawrencite.—This mineral, so-called by M. Daubrée, I first found in the Tazewell meteoric iron as described by me in 1853,§ and still later in the Rockingham iron. It is a solid green protochloride of iron with probably nickel. The quantity obtained was small and could not be analyzed.

* Comptes Rendus de l'Acad. des Sciences, 1876.

† This Journal, vol. xvi, Oct., 1878, will be found a full and complete account, analyses, etc.

‡ Comptes Rendus de l'Acad. des Sciences, 1881.

§ This Journal, vol. xix, p. 151, 1853.

Aragonite.—I first discovered carbonate of lime in small quantity concreted on the Newton County meteorite,* a stony meteorite. It was in the form of calcite. In 1876 I found considerable of a crust of aragonite on two specimens of the Butcher meteoric iron from Mexico.† But in neither of these instances do I consider the carbonate of lime as belonging to original meteorites, the incrustations having taken place after their fall. But all the other concretions referred to came originally with the meteorites.

Each of the concretions enumerated, in all six excluding the last, is almost as characteristic of meteoric iron as the nickeliferous alloy of the metal. It is true that we find graphite segregated in artificial iron from the blast furnace, but in this iron it is always in crystalline flakes, which I have not found in meteoric iron.

The above facts do not exhaust the interesting facts connected with these concretionary minerals of meteoric iron—for some of them, if not the majority, are somewhat complex in their character, being mixtures of the various substances found in two or more of the purer nodules; and besides there are other compounds not visible to the naked eye and only reached by chemical means. I will describe some of them that are complex and give the method of separating the different compounds.

Before, however, passing to this part of the subject I will say a word about *Celestialite*, for, while it does not occur in a concreted form in any part of meteoric iron, it is found associated with the graphite, and also in the troilite containing graphite. A full description of it has already been given.‡ M. Berthelot has supposed that the ether used in the experiments had something to do with its formation, but I have since repeated all my former experiments with petroleum ether in his presence with similar results.

There is also an undefined *Cobalt mineral* occurring in the troilite of some of the veins, which will be referred to beyond.

Compound nodules.—The difficulty of obtaining a sufficient quantity of these concretions from many irons, has circumscribed my research to those coming from three irons: 1st, the Toluca iron, which furnished material in sufficient quantity only for a partial examination; 2d, the Cranbourne; and 3d, the Sevier County—the latter two furnished the principal materials for my research.

I will simply detail my process with the results from the

* This Journal, vol. xliii.
† This Journal, vol. xii, 1876.
‡ This Journal, May and June, 1876.

treatment of a nodule of eight grams of a compound troilite nodule from the Cranbourne iron, for this is most accessible to any one desiring to repeat the experiments. This nodule was very finely powdered and treated with petroleum-ether (boiling under 72° C.) for about one hour, filtered and washed with the same petroleum, and the entire amount of liquid evaporated slowly to dryness. This gave me a few minute crystals of *celestialite* mixed with sulphur. But as this substance is so enveloped in the mineral matter, it is only in a subsequent part of the process that the greater part of the celestialite is obtained.

After the treatment by petroleum, the dried powder is treated by dilute chlorhydric acid (1 acid to 1 water) and warmed over a water bath for an hour or two, and after all action has ceased more acid is added (1 acid to 1 water) for about half an hour; this will dissolve entirely all the troilite with the evolution of SH_2, leaving a black residue. The solution of troilite is filtered and the residue washed. The troilite solution was analyzed and found to contain a very minute quantity of nickel, 0·40 per cent, and the merest trace of cobalt; sometimes more of the cobalt will be found than nickel, but this arises from another mineral in the compound nodule that has been partially attacked. The residue was then treated with petroleum-ether in the manner already stated, and the filtered solution on slow evaporation in a small beaker gave beautiful long needle-shaped crystals that weighed ·045 grams—a mixture of sulphur with a sulphur-carbon compound. The residue from the last irons was treated twice over a water bath with strong chlorhydric acid, and the soluble portion filtered off and concentrated gave a greenish-blue solution which heated with nitric acid did not acquire a red color and on analysis was found to contain cobalt-oxide with a little nickel, ·028; iron oxide, ·105; chrome oxide, ·008. The little chrome coming from the amorphous daubréelite to be alluded to a little further on. The residue from the last was dried on a water bath and spread out carefully and a magnet applied to it, when a large portion of it was attracted, amounting to ·603 grams, composed of microscopic square prismatic crystals which doubtless were what G. Rose called Rhabdite,* but which is schreibersite for I have obtained it from other meteoric irons by treating them with chlorhydric acid, and then verifying the composition of the crystals by analysis.

The part which was not magnetic was then treated with nitric acid, evaporated to dryness, and treated again with a little nitric acid and water and filtered; an intensely green solu-

* Rose found it in square prismatic crystals in the Braunau iron, but he could not determine either its composition or precise crystalline form.

tion is obtained, composed of Cr ·010, Co ·015, Fe_2O_3 ·028; in fact it is daubréelite with cobalt and oxide of iron coming from an unknown cobalt compound that had made itself very manifest in a previous part of the examination.

The residue, which has been now reduced to a few milligrams, is found to be graphite with a few minute particles of a siliceous mineral. The only novel feature of importance in the results above stated is the appearance of considerable amounts of cobalt in certain parts of the process. It is evident that this is not a part of the composition of the troilite, for chlorhydric acid removes this latter mineral and but a trace of cobalt is found in the solution; it is only after further and prolonged treatment with concentrated chlorhydric acid that the cobalt appears abundantly in solution with comparatively little iron; and it even requires a further treatment with nitric acid before it is all dissolved; then it is mixed with the daubréelite. My conclusion is that it comes from a mineral in the compound nodule first operated with, in which cobalt is a prominent constituent; but whether it is a sulphuret or phosphuret I have no means of ascertaining, but in order to note its prominent position I have thought proper to state this fact. In the analyses of troilite nodules, I have several times noticed that when they are completely dissolved, while but a trace of nickel is found, a notable quantity of cobalt manifests its presence.

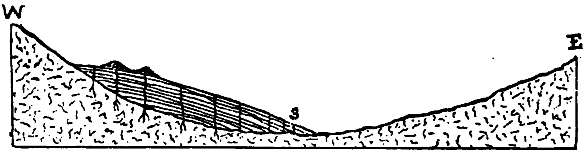
These are the prominent points that I wish to call attention to at this time as regards these concretions. The question naturally arises, do they in any way serve to indicate the manner in which the original masses were formed. While it is impossible from what we yet know to clear up this question, I am more and more confirmed in the belief that the iron was at one time in a plastic state from the effect of heat. Some may think otherwise from the fact that petroleum-ether dissolves sulphur and sulphur carbon compounds from the concretions in the iron. But the fact is that my observations and experiments on cast iron show that this objection has no weight. As by a proper treatment I dissolve crystals from most cast iron by the agency of ether or petroleum-ether—a note of which fact I have already publicly announced—my experiments on this point are both clear and convincing although I have not yet completed them. So far as they have gone they were shown experimentally to M. Berthelot and others, and if my health permits I shall complete them before many months.

ART. XLIII.—*On Mineral Vein formation now in progress at Steamboat Springs compared with the same at Sulphur Bank;* by JOSEPH LECONTE.

I RECENTLY visited Steamboat Springs for the purpose of comparing the phenomena there exhibited with those previously observed at Sulphur Bank and described in this Journal of July last. These springs have already been described by Phillips and Laur.* I shall, therefore, give only such brief description as is necessary to make my comparison intelligible.

The springs are in Washoe Co., Nevada, about fifteen miles south of Reno and immediately on the railroad to Carson and Virginia City. The place is, therefore, easily accessible, and, being a health-resort, there are good accommodations for visitors. The springs issue in a narrow N. and S. valley with volcanic ridges on each side, the vents being mainly on the slope of the western ridge. On nearing the place by cars, the attention of the traveler is strongly attracted by the clouds of condensed steam issuing from many vents over a bare rocky space about the hotel and extending northward a half mile or more. On closer examination the vents are seen to be separate, but occurring in linear series, showing that they are connected by continuous fissures. These fissures may be traced from vent to vent often as a vein, filled by a deposit of silica from the hot alkaline waters. The separate vents, especially at the south end of the fumarole area, are each on the top of a gently sloping mound (some of which are 15 to 20 feet high) formed by deposit from the water. The mounds, however, run together at their bases and form a continuous crust of silica. Toward the northern part of the area the crust is still more evenly continuous. It forms here, in fact, a continuous rounded shell-like deposit, firm, hard, and ringing under the

1.

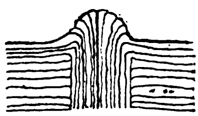


heel, about 2 to 3 hundred yards wide, at least a half mile long and 15 to 20 feet in thickness. This clean, hard, shell-like crust lies against the slope of the western hill and reaches to near the bottom of the valley. (Fig. 1.)

* Laur, Annales des Mines, for 1863, p. 423. Phillips, Phil. Mag., 1871, vol. xlii, p. 401.

We have said that about the hotel the vents are mostly separate but arranged on lines which were evidently fissures. These fissures are some of them open, some partly filled but water still issuing from a narrow crevice in the middle, some wholly filled with deposit. The deposited silica occurs in almost every conceivable form—most commonly as tufaceous sinter in thin horizontal layers, sometimes with beautiful agate-like structure, sometimes milky chalcedonic, and sometimes saccharoid quartz. Everywhere the horizontal-banded structure is conspicuous and in some cases the filling of fissures by successive deposits has given rise to a vertical banded structure like that found in veins. Fig. 2 is an ideal section of such a vein of the natural size. This structure, however, was by no means so conspicuous as I had been led to expect from the descriptions of previous observers. The deposits in many places are stained and clouded with metals, especially iron oxide and cinnabar. Wherever the issuance of the hot water is still going on slowly the silica is found in a gelatinous condition. Other observers have found in small quantities many other metallic sulphides, and even free gold is said to have been found in these sulphides. Here then undoubtedly mineral veins are now forming under our eyes, but their metallic contents are in very small proportion.

2.



In the more northern portion of the fumarole area, as already stated, the crust is more continuous and extensive and probably thicker. This part was therefore probably at one time the principal seat of fumarolic action, but the active vents are now very few. This whole area is intersected by a system of open parallel fissures of great size and differing somewhat from those already mentioned. They are seven or eight in number, and the five largest are at least half a mile long, a foot wide, about twenty-five feet apart and apparently 20 to 30 feet deep. They are tortuous with rough ragged edges and evidently reach to the bottom of the crust. Water does not now issue from them but can be seen and heard seven or eight feet below, in violent agitation from the escape of steam and carbonic acid (fig. 1). There is no evidence that it ever issued from them; for their sides and edges are sharply jagged like a fracture unmodified by subsequent deposit. The water in them seems to issue lower down to the east and north, where are found active vents and even feeble geyser eruptions which are said to have been more violent at one time than now.

It will be seen then that there are indeed here fissures filled and now filling with quartz veinstone of ribboned structure and containing metallic sulphides, yet these are not fissures and

veins in the country rock, but only in the *crust deposit.* The country rock is completely buried under this crust probably 20 to 30 feet deep, and therefore completely concealed from view. The hot alkaline waters loaded with silica seem to have deposited so abundantly that they cover and choke up their own vents, while other vents are constantly formed by the expansive force of steam fissuring the crust previously formed. The great fissures described above were probably formed in this way, and perhaps opened by a slight bodily sliding of the crust toward the bottom of the valley. The analogy of the filled fissures to veins is not so complete as I had expected, or as it is at Sulphur Bank. If we could get beneath the crust and find fissures in the country rock filled by deposit, then indeed the analogy would be complete. This is exactly what we actually find at Sulphur Bank. In the immediate fumarole area, the country rock is concealed, but wherever not covered by deposit its character is evident. On the hill slope and in the valley to the very margin of the deposit it is everywhere a quartz-trachyte or rhyolite. Along the crest of the western ridge, however, there is an outburst of black, very basic rock, probably basalt. This ridge is probably a basaltic dyke breaking through a rhyolitic country rock. It is not improbable that the fumaroles are the feeble remnants of a volcanic activity inaugurated by the basaltic outburst.

Cinnabar mines in the vicinity.—About a mile to the westward of the springs, cinnabar mines have been opened and reduction works established. A considerable amount of cinnabar has been taken out, but the work is now abandoned. Here the surface appearances are entirely different from those at Steamboat Springs, and more like those at Sulphur Bank. There is no crust deposit, but on the contrary the whole hillside rock is decomposed by acid vapors into a white chalky earth like that at Sulphur Bank, except that in this case the rock being rhyolite, the chalky earth is full of disseminated grains of free quartz. Tunnels have been driven into the hillside at various levels and the ore extracted from the decomposed earthy matter, but the sound rock has not been reached. In this loose earth are found in considerable quantities both cinnabar and sulphur—the former in streaks as if deposited in water-ways, the latter more irregularly and widely distributed as if formed by oxidation of sulphuretted hydrogen gas. In some places sulphates of iron and alumina are very abundant, even more so than at Sulphur Bank. There can be no doubt, therefore, that here there came up, and probably are still coming up, hot waters containing alkaline carbonates and alkaline sulphides, carrying in solution and depositing sulphides of mercury and iron by cooling, and by oxidation depositing also sul-

phur and forming sulphuric acid. In a word the phenomena are here very similar to those at Sulphur Bank, except that here the up-coming solfataric waters are less abundant and perhaps less rich in metallic sulphides. This, however, can only be determined with a certainty by deep explorations.

Comparison of Steamboat Springs with Sulphur Bank.—A comparison of the phenomena at these two places is interesting. The surface phenomena, it is seen, are very different; in fact in complete contrast. At Steamboat Springs the whole country rock is covered 20 to 30 feet deep and completely concealed by a hard crust of deposited silica; at Sulphur Bank, on the contrary, there is no crust but only a soft chalky residue from the acid decomposition of surface rock—a residual silica from which the bases have been all extracted. The reason of the difference is obvious. At Steamboat Springs the hot waters contain mainly alkaline carbonates carrying silica in solution, while at Sulphur Bank they contain also largely alkaline sulphides and carry metallic sulphides in solution. A crust cannot form at Sulphur Bank because the silica is not brought to the surface, the up-coming alkaline waters carrying silica being neutralized before reaching the surface by the down-going acid waters. The chalky residues of acid decomposition of the surface rocks, so conspicuous at Sulphur Bank, do not occur at Steamboat Springs, because the alkaline sulphides are in too small proportion to produce any conspicuous effects by oxidation; whatever of rock decomposition occurs there, must be alkaline, not acid—by removal of silica, not of bases. Such alkaline decomposition doubtless does occur beneath the crust at Steamboat as it does at Sulphur Bank below atmospheric influences. Again, since alkaline sulphides are the solvents of metallic sulphides, at Steamboat Springs the deposits are almost pure silica—only stained here and there with metallic oxides and sulphides; while at Sulphur Bank the metallic sulphides, especially mercuric sulphide, are in large quantity. At the abandoned cinnabar mines near Steamboat Springs, alkaline sulphides, carrying metallic sulphides, again occur, but here again also, these are associated with the surface phenomena characteristic of solfataric waters.

At the California Geysers—so-called—we find also solfataric action with its invariable accompaniment of acid decomposition of the surface rocks with earthy residue, but the freight of valuable metallic sulphides seems to be less abundant there, probably only because not met with in the course of the up-coming waters. Iron sulphide, however, is abundantly deposited. In *true* geysers like those of Yellowstone Park and Iceland, the super-heated waters contain usually only alkaline carbonates, and therefore carry in solution and deposit only silica.

Thus then, we have a connected series of deposits from super-heated waters, their characters depending upon the composition of these waters: 1. In true geysers the waters being pure alkaline carbonates deposit only silica. 2. At Steamboat Springs there are some alkaline sulphides, and, therefore, some metallic sulphides, but not enough to prevent a crust of deposited silica. 3. At the California Geysers—so-called—solfataric action is conspicuous and therefore no crust is formed, but only earthy residue of acid decomposition of surface rocks. Here we have also metallic sulphides deposited, but these are of little value. 4. At the cinnabar mines, near Steamboat Springs, we have solfataric waters depositing cinnabar and other metallic sulphides in considerable quantity, but whether in profitable quantity cannot be known certainly unless deeper explorations be undertaken. 5. Finally, at Sulphur Bank, the deposit of metallic sulphides is abundant and the formation of metalliferous veins is illustrated in the most perfect manner on account of the deep explorations undertaken at this place.

In connection with the idea so common, that the metals are derived immediately from igneous rocks, it may be well to draw attention to the fact, that igneous rocks are by far most abundant and igneous action most conspicuous at Yellowstone Geysers and at Steamboat Springs, where there are little or no metals; while at Sulphur Bank the country rocks beneath a depth of 20 to 30 feet are stratified sandstones and shales of Cretaceous age, the igneous rocks being very superficial and evidently contributing nothing to the metalliferous deposits. It would seem that igneous *action* supplies a necessary *condition* (heat) for the formation, rather than that igneous *rocks* supply the *materials* of metalliferous veins.

ART. XLIV.—*Observations of the Transit of Venus, Dec. 6th, 1882, at the Vanderbilt University Observatory, Nashville, Tenn.;* by OLIN H. LANDRETH, Professor of Engineering, Vanderbilt University.

BY the courtesy of Dr. L. C. Garland, Chancellor and Professor of Astronomy of this institution, in granting me the use of the University Observatory during the Transit of Venus of Dec. 6th, 1882, I am enabled to make the following report of the observations and results obtained in connection therewith. All times here expressed are in terms of Washington mean time, and are dependent on the value of the longitude herein given.

Observations of external and internal ingress were wholly

prevented by clouds which continued to obscure the sun almost without interruption until $6^d\ 1^h\ 12^m$, after which the sky remained clear during the day.

Instrumental Constants and Circumstances.

Adopted latitude of equatorial dome $= +36°\ 8'\ 58''.25$.
Adopted longitude of equatorial dome $= +0^h\ 39^m\ 0.68^s$ from Washington.

Aperture of equatorial	=	5·95 inches.
Focal length of equatorial	=	97·00 inches.
Magnifying power used	=	210 diameters.
Value of one revolution filar micrometer screw I	=	21″·1803.
Value of one revolution filar micrometer screw II	=	21″·1297.
Diameter of cross-wires in filar micrometer	=	less than 0″·34 (15 measurements).
Aperture of transit circle used for time determination	=	3·92 inches.
Focal length of transit circle used for time determination	=	54·00 inches.

The adopted latitude and longitude depend on the position of the astronomical station of the U. S. Coast and Geodetic Survey, located on the grounds of the Tennessee State Capitol in Nashville, which station was connected with the Vanderbilt Observatory by a traverse survey executed by my engineering students, with an engineer's transit and a suspended fine steel wire corrected for deflection, temperature and inclination. The adopted value of the astronomical position of the coast survey station as furnished me by the office is:

Latitude $= +36°\ 10'\ 1''.37$.
Longitude $= +0^h\ 38^m\ 55.897^s$ from Washington.

The adopted clock correction—the probable error of which is $\pm .066^s$—is the result of twenty star transits extending from Dec. 5.3^d to Dec. 6.5^d, including four circumpolar pairs for azimuth, three reversals for collimation and seven level readings, all systematically distributed, and reduced by least squares involving unknown quantities for azimuth, collimation, clock rate and correction to the assumed clock error.

The value of one revolution of the micrometer screw was determined by eighty-one transits of equatorial stars covering a range of temperature of 20° C., without revealing any temperature effect. The quantity ″·34 stated in connection with the diameter of cross-wires in the filar micrometer is one-half the "double distance" between the two positions of symmetrical tangency of one wire with the other, as determined by the narrowest possible line of light visible between the two wires.

Final Results.

Times of Contacts.

Internal egress "suspected,"	(*a*)	Dec.	$6^d\ 2^h\ 40^m\ 10.3^s$	Washington mean time.
" " "certainly past,"	(*b*)	"	$6^d\ 2^h\ 40^m\ 28.0^s$	" "
External egress "suspected,"	(*c*)	"	$6^d\ 3^h\ 1^m\ 9.3^s$	" "
" " "certainly past,"	(*d*)	"	$6^d\ 3^h\ 1^m\ 23.8^s$	" "

Filar Micrometer Measures of Planet's Diameter.

Polar diameter = $62''.941$ (4 observations), mean at $2^h\ 25^m\ 6^s$.
Equatorial diameter = $63''.247$ (4 observations), mean at $2^h\ 34^m\ 35^s$.

Remarks on the Observations.—Concerning the phenomena seen at the two recorded instants (*a*) and (*b*) my note-book says: "The two recorded times at third contact are those at which the narrow band of light between the sun's limb and planet became so narrow and faint as to cause 'suspicion' and 'certainty' of its being only the light around the planet. At 10^s or 11^s after 'suspected,' (*a*), I glanced to see if tangency had yet occurred and found it, as near as I could judge, perfect, and again saw it certainly past just before 'certainly past,' (*b*), which was recorded when the narrow band of light had *certainly* quieted down into a *Venus halo.*" This closed band of light continued visible for about 20^s after (*b*), and remained as an arc of 45° from sun's limb on north side of planet until $2^h\ 48^m$. At fourth contact the recorded times (*c*) and (*d*) are those at which the obliteration of the notch on the sun's limb was "suspected" and "certainly past." The obliteration was accompanied by a rather more than usual disturbance at this point of the limb of the sun. Through the kindness of Capt. G. W. Stockell, Chief of the Fire Department of Nashville, time signals were struck on the fire-alarm bells of the city at $8^h\ 00^m\ 1^s$ A. M. and at $2^h\ 00^m\ 00^s$ P. M. Vanderbilt mean time. Time was taken and recorded for me during the observations by J. T. McGill, Ph.D., Fellow and Assistant in Chemistry. I am also indebted to Assistant Engineer W. B. Boggs, U. S. N., Instructor in Engineering, for assuming charge of the distribution of time signals, as well as to C. L. Thornburg, B.E., Fellow and Assistant in Mathematics, for efficient and extended assistance in the determination of time and instrumental constants. In order to give Mr. E. E. Barnard the advantages of the observatory time-determination and geographical position, he was invited to observe the Transit from the observatory grounds. This he did, having his time-sounder in electric circuit with the observatory sidereal clock. His results are given in his letter appended. I am gratified to be able to state that Mr. Barnard has since been appointed to a fellowship in astronomy in this institution.

March 30, 1883.

Transit of Venus, Dec. 5th and 6th, 1882; as observed by Mr. E. E. Barnard.

Latitude $+36°\ 8'\ 57''.88$. Longitude $39^m\ 0^s.781$ west from Washington.

The following are Observed Times of Phenomena described, Washington mean time.

II.	III.	*a.*	*b.*	IV.
$21^h\ 16^m\ 32^s$	$2^h\ 40^m\ 50^s$	$2^h\ 41^m\ 40^s$	$2^h\ 46^m\ 29^s$	$3^h\ 1^m\ 15^s.78$

Point of observation, about 200 feet west of Vanderbilt Observatory telescope. Five-inch Byrne refractor mounted as a simple equatorial, with tangent screw motion in R. A. Magnifying power for contacts 173, used with wedge-shaped sun prism. Time obtained from the observatory by means of a telegraphic *sounder* beside the observer, and in circuit with the observatory Dent sidereal clock. Several minutes before and after calculated contacts, the minutes and intervening ten seconds were called from the observatory.

First contact lost in dense clouds.

Second contact uncertain, the sun being glimpsed for a moment; Venus seen, I am confident, at or very close upon contact; this time is noted as II. Clouds until afternoon. When a view was permitted, careful observations were made; no light spots seen. An optical phenomenon was constantly present, a large brown spot two-thirds the diameter of Venus covering the middle of the planet; viewed obliquely it was thrown slightly to one side staining the sun a bright yellow; the planet otherwise was of a violet color; brown spot only seen with high powers. Several times a faint ring of light was noticed around Venus, only certainly seen when thin clouds cut down the bright background.

Third contact, definition very poor from heated air, and too much reliance should not be placed on this observation; black drop formed before the limbs were quite in contact; the time, III, was when the limbs were tangent, as estimated through the black drop, and probably a little late. A small arc of light was visible round Venus at the point of contact, which at time marked *a* was protruding sensibly outside the sun. This outlining of the planet's protruding limb remained visible for several minutes, the arc increasing as the planet emerged; presently about two-thirds of the arc to the northwest entirely disappeared, leaving a delicate horn of light projecting from the sun's limb around the southern part of Venus; this remained quite conspicuous until the time marked *b*, when it disappeared completely, though closely looked for; no similar object was visible at the other side of the planet.

At fourth contact, definition was much improved. The last glimpse of the planet against the outline of the sun was that marked IV; a few seconds later Venus was certainly gone. I think this observation can be relied on as being very close.

Full aperture was used at second contact without any sunshade. The other observations were with aperture reduced to 4½ inches.

ART. XLV.—*On the Fauna found at Lime Creek, Iowa, and its relation to other Geological Faunas;* by S. CALVIN, State University of Iowa.

A PAPER by Professor H. S. Williams, in this Journal for February, 1883, "On a remarkable Fauna at the base of the Chemung Group in New York," appears to me to record more than one remarkable discovery. The finding of fossil species at High Point, New York, identical with species that have heretofore been known only from the Rockford Shales, along Lime Creek above Rockford, Iowa, is a most interesting fact and well deserves immediate record. In discussing the significance of his discovery, however, the author of the above-mentioned paper, misled no doubt by information from untrustworthy sources, has fallen into a few errors that, in the interest of clearness in geological matters, should be set right.

For the better understanding of the questions involved let me give a catalogue of the Lime Creek fauna as far as the species have been described. Some of the species enumerated below have not been catalogued from this locality by previous writers, but my own collections, made personally, embrace all the species of this list, except *Leiorhynchus iris* which is included on the authority of Mr. R. P. Whitfield.

Stromatopora incrustans H. & W.
Stromatopora expansa H. & W.
Stromatopora solidula H. & W.
Caunopora planulata H. & W.
Fistulipora occidens H. & W.
Alveolites Rockfordensis H. & W.
Aulopora Iowensis H. & W.
Aulopora saxivadum H. & W.
Zaphrentis solida H. & W.
Campophyllum nanum H. & W.
Chonophyllum ellipticum H. & W.
Cystiphyllum mundulum H. & W.
Pachyphyllum solitarium H. & W.
Pachyphyllum Woodmani White.
Acervularia inequalis H. & W.
Smithia Johanni H. & W.
Smithia multiradiata H. & W.
Stomatopora alternata H. & W.
Crania famelica H. & W.
Strophodonta arcuata Hall.
Strophodonta canace H. & W.
Strophodonta variabilis Calvin.

Strophodonta exilis Calvin.*
Strophonella reversa Hall.
Strophonella hybrida H. & W.
Streptorhynchus Chemungensis Con.
Orthis impressa Hall.
Productella dissimilis Hall.
Productella truncata Hall.
Spirifera Whitneyi Hall.
Spirifera Hungerfordi Hall.
Spirifera orestes H. & W.
Spirifera cyrtinæformis H. & W.
Spirifera fimbriata Con.
Spirifera Macbridei, n. s.†
Cyrtina Hamiltonensis, var. *recta* H.
Atrypa reticularis Lin.
Atrypa hystrix Hall.
Rhynchonella contracta, var. *saxatilis* H.
Leiorhynchus iris Hall.
Leiorhynchus (undescribed species).
Gypidula occidentalis Hall.
Terebratula navicella Hall.
Cryptonella Calvini H. & W.
Paracyclas Sabini White.
Naticopsis gigantea H. & W.
Undetermined *Orthocerata*.
Plates of Placoderm fishes allied to *Dinichthys*.

That the High Point fauna, as given by Professor Williams, bears a close resemblance to the Lime Creek fauna, will be admitted by all competent judges; but that a fauna in which Atrypas and Strophodontas predominate among the brachiopods, and which includes Alveolites, Acervularia, Smithia,

* This species was described by me in the Bulletin of the United States Geological Survey of the Territories, vol. iv, No. 3, as *Strophodonta quadrata*. This name, however, was preoccupied by Professor Swallow (Proceedings St. Louis Academy of Science, 1860), and I, therefore, propose to substitute the above name in place of that originally applied.

† This fine species of Spirifera is not very rare in the Rockford Shales. It differs from all described forms in many important particulars. The shell is of medium size, more or less pyramidal or cyrtina-form; hinge line equal to greatest width of shell but with the cardino-lateral angles scarcely produced. Ventral valve sub-pyramidal, hinge area very wide and slightly concave, the plane of the area forming an acute angle with a plane passing between the valves. Mesial sinus broad, shallow, with a low, rounded ridge down the middle. Dorsal valve slightly convex, mesial fold well defined regularly rounded, protruding in front in the middle line owing to the ridge in mesial sinus of opposite valve. From twelve to fourteen low, rounded plications on each side of the mesial fold and sinus, which are large near the middle of the shell, and decrease toward the lateral margins. Entire surface very finely granulose; the granules in some places, particularly on the mesial fold and sinus, being arranged in very close-set, radiating lines. Imbricating lamellæ and lines of growth are crowded concentrically on the anterior half of each valve. Length, 23^{mm}, width 36^{mm}. Height of hinge area, 16^{mm}. Width of foramen at base, 10^{mm}. This species is named in honor of Professor T. H. McBride of the State University of Iowa.

Chonophyllum and Cystiphyllum among its corals, is "*strikingly Carboniferous in aspect*" (this Journal for February, p. 98) is an opinion that will not be shared by many paleontologists. Even the little Productus, *Productella dissimilis* Hall, that Professor Williams regards as so "*decidedly Carboniferous in aspect*" (10th line, 1st par.) is a true Devonian type; and there is not another species in the whole list that even remotely suggests any Carboniferous affinities.

Spirifera fimbriata, as far as I know, occurs in eastern strata belonging to the Upper Helderberg and Hamilton; not in the Chemung. Now the specimens found at Lime Creek agree in size with the Upper Helderberg rather than with the Hamilton forms, a fact that, so far as it has any significance, points toward the lower Devonian rather than in the opposite direction.

Several years ago I found a few cystideans in Devonian strata near Iowa City, one of which has been described by Dr. C. A. White as *Strobilocystites Calvini*. Previous to this discovery it had been very generally supposed that the cystideans became extinct in the Upper Silurian; certainly they did not persist very far into the Devonian. Nevertheless, last year, at another locality near Iowa City, I found the Lime Creek species, *Productella dissimilis* and *Spirifera Whitneyi*, in a thin bed of shale *associated with plates of cystideans*. The significance of this fact does not need to be stated.

Then again, in 1876 and 1877, a number of Lime Creek species, including *Productella dissimilis*, were found associated with a peculiar fauna in some black shales below the limestones at Independence, Iowa. This fact was noted by me in a paper published in the Bulletin of United States Geological Survey, vol. iv, No. 3, in 1878. The Independence limestones have been referred by all geologists who have studied them, to the Hamilton, though Dr. Barris refers beds containing a similar fauna at Davenport, Iowa, to the Upper Helderberg. *Acervularia profunda*, *A. Davidsoni*, *Phillipsastrea gigas* and some other species that occur in the Independence limestones, are found in strata that have been referred to the horizon of the Upper Helderberg in Canada and Ohio. For a shell with a "decidedly Carboniferous aspect," *Productella dissimilis* has the somewhat questionable habit of always keeping company in Iowa with Lower Devonian types.

In a note in this Journal for April, p. 311, Professor Williams withdraws the statement near the top of page 99, that Professor Worthen had referred the Lime Creek beds to the Kinderhook; but the statement farther on, on the same page that "the Lime Creek fauna is certainly more closely related to the fauna of the Kinderhook group of Missouri, Indiana and Illinois than

to any other fauna of the West," should not be accounted for on the theory of misleading publications in respect to western geology. In fact, not a single species of the Lime Creek fauna has yet been recognized in all the Kinderhook of Missouri, Indiana and Illinois. Not only are all the known species different in the two formations, but very few even of the Lime Creek *genera* are represented in the Kinderhook. Of the Atrypas and Strophodontas that constitute so conspicuous a feature of collections from Lime Creek, the Kinderhook has not so much as a single representative. It would be a more hopeful undertaking to attempt to prove a close relationship between the fauna of Lime Creek and the fauna of the Niagara than to prove such relationship between the Lime Creek and Kinderhook faunas. At least one species is common to the first two, the *Atrypa reticularis*, and the genera are strikingly similar as shown in the following table:

Niagara.	Lime Creek.	Kinderhook.
Stromatopora,	Stromatopora,	
Alveolites,	Alveolites,	
Cystiphyllum,	Cystiphyllum,	
Strombodes,	Smithia,*	
Strophodonta,	Strophodonta,	
Strophonella,	Strophonella,	
Streptorhynchus,	Streptorhynchus,	Streptorhynchus,
Orthis,	Orthis,	Orthis,
	Productella,	Productus,
Spirifera,	Spirifera,	Spirifera,
Atrypa,	Atrypa,	
Pentamerus,	Gypidula,	
Rynchonella.	Rhynchonella,	Rhynchonella.

Some genera omitted from the Lime Creek list are not represented in either of the other two groups. A glance at the table will show on which side the relation is most marked, and yet I think few geologists would claim that any very close relationship exists between the Lime Creek and Niagara faunas.

The fish faunas of the Lime Creek and Kinderhook beds do not help matters very much. In the first we have fragments of plates of Devonian Placoderms; in the second we have beds crowded full of the teeth of *Cladodus* and other Carboniferous Hybodonts.

The last sentence of Professor Williams's brief note in the April number of this Journal might have been omitted. "The exact relation of the Lime Creek beds *to other deposits of the west*" is not in question so far as I know; but the particular New York horizon with which, not only these beds, but all our Devonian strata are to be correlated, is questioned by some and hence "not satisfactorily determined." The discovery at

* The two species of Lime Creek fossils referred to *Smithia* are certainly not generically distinct from *Strombodes*. (See remarks of Rominger on this point, Geol. of Mich., vol. iii.)

High Point, N. Y., would seem to indicate that the Lime Creek beds are equivalent to the lower part of the New York Chemung; yet it must be conceded that the mingling of Upper and Lower Devonian features in the Lime Creek fauna, and in all the Devonian fauna of Iowa as well, leaves the question of exact equivalency still doubtful.

Speaking for the Kinderhook beds of Iowa and Illinois,* it may be positively asserted that Devonian types are wholly absent from the included fauna; while the Hybodont fishes, the Crinoids, the representatives of the *Productidæ*, and other groups of fossils, all assume Carboniferous features which ally the Kinderhook with the Burlington and other undoubted Subcarboniferous strata.

ART. XLVI.—*Observations upon Stratified Drift in Delaware;* by F. D. CHESTER.

IF a line should be drawn from the city of Wilmington to the village of Newark until it touched the Maryland boundary line, it would follow approximately the southern limit of the Archæan rocks of the State. These gneissic and schistose strata strike in the common northeast and southwest direction and dip at high angles to the southeast. Resting upon the southern flanks of the latter rocks, occur unconformable Cretaceous strata, whose subdivisions and positions exactly correspond to those of the New Jersey series. The dip of these latter Cretaceous clays, sand and marls is so small that the surface of the country is extremely level. The Archæan region, on the contrary, is one mass of hills, separated not by wide but by extremely narrow valleys, and generally by mere hollows, depressions or ravines.

Examinations throughout this hilly country point distinctly to the fact that these elevations and depressions have been carved out by the forces of erosion—these forces being ordinary aerial disintegration of the gneissic and schistose rocks, and erosion along drainage lines.

That mere hollows entirely surrounded by hills could have been dug out only by aerial disintegration is certain. These enclosed hollows serve to separate the majority of all the elevations of this Archæan region. Often hollows connect hollows by short passages, the hills sloping in all cases gradually. Often, again, hill-slope will meet hill-slope, while the ravine separating winds along for distances varying from a few hundred feet to several miles. Still oftener it is seen that hill

* Some authors still regard the Goniatite beds of Rockford, Indiana, as possibly Devonian.

slopes are scarred by broad shallow gouges. To describe all the details of form in this irregular but picturesque region would be impossible, but what has already been said suffices to present the main forms of relief. That many of these forms must be attributed to direct aerial disintegration of the rock, now going on with such rapidity in this region, is quite certain.

The main reason for this may be attributed to the varying power of durability which these rocks are known to possess. Some of them, those containing an excess of black mica, resist to some extent the forces of disintegration, while those mainly composed of feldspar easily decay. We know further, as practically observed in this region, that this rock disintegration is carried on more through the presence of moisture and soakage waters than through direct atmospheric contact, hence no doubt the collection of waters in hollows and along certain lines has been a great factor in the work.

But that this erosion was not entirely aerial in character is evident. The creeks of the region wind for miles through valleys, no doubt largely due to their own waters; for the flat lands of the valleys, wherever observed, are underlaid by stratified sands and rock fragments, all of gneissic origin. Into the valleys open narrow ravines, usually the course of some brook, and underlaid by the highly stratified gneissic sand and fragments. These ravines wind in and out for miles, and were no doubt once the channels of larger streams. Into these latter ravines still other ravines are often found to enter. The last system of valleys and ravines we must regard as the work of running water, but even in this case aerial disintegration must have acted also; for the sides of these valleys and ravines are the steeply sloping hills, the soil of which has resulted from the decay of the underlying rocks.

Thus the two main forces of erosion throughout this Archæan country have been aerial decay and erosion. Wherever the former force has acted, the soils are disintegrated rock in place, *and such is characteristic almost entirely of this region*, while, wherever the latter force has acted, the flat lands of the valley and ravine are made of stratified materials.

If now we extend our examinations of the surface geology south of the Archæan hills, to the drift deposits which overlie the Cretaceous clays, we find a different order of things. Instead of the common gneiss-made soil in place, we find no connection between surface deposits, and the underlying formation. Examinations of the soils from various localities determine clearly their gneissic origin. Quartz grains, finely rounded, hornblende particles, rounded but with less smooth surfaces, particles of white mica and rarely grains of magnetite. The

clay present was the element giving variety of color to the soils and was found coating and cementing the particles.

To sum up the results of numerous observations upon the surface deposits we have the following general section:

Surface soil	6″—18″
Yellow clay	6′—14′
Red sand and water-worn pebbles, highly stratified	4′—12′

The yellowish clay shows clearly its gneissic origin. This bed when seen wet in the digging of wells has the appearance of being highly plastic, but when dried this coherence is lost and the material is found to be made up of very fine particles of gneissic origin. The red sand was entirely free from clay and was merely the coarser materials of gneissic origin, constituting water-worn quartzose pebbles, fragments of gneiss and mica schist, coarse particles of mica and coarse quartzose sand colored red by the oxide of iron resulting from the decomposition of hornblende.

That this latter bed of red sand does not form a part of the Cretaceous clays is proven by the fact that it is also found to overlie the upturned edges of the Archæan strata along their southern margin, just at the foot of the hills. Further the complete absence of the red sand in the region of the marl beds would indicate its gradual thinning out before that point is reached, while the overlying clays continue on to the south and directly cover the true geological formations. This latter surface deposit extends to the lower limit of New Castle County, beyond which point examinations have not been carried. Besides the thick layer of argillaceous soil extending from the Archæan hills to the lower limit of our explorations, there are often seen, in the southern portion of the county, local patches of white and yellow quartzose sand, which show no apparent stratification, and were probably of dune origin.

Still further we have to note certain peculiarities of the surface geology of Delaware. The Cretaceous plain, just south of the gneissic hills, is characterized by swells and undulations of the land, which gives the country in places a gently rolling character. These swellings are found to be made up of the stratified yellowish loam, mixed with rounded quartzose pebbles. It often happens that this stratification of the soil was no way appparent, but whenever the materials became coarse, such stratification was distinctly seen.

The exact position of these forms in the classification of drift phenomena is uncertain, unless they be termed, after Hitchcock, *Terrace-moraines*. Their origin is still more uncertain, and the only probable explanation is some checking of the motion of the waters at certain points, whereby a greater amount of material was deposited in particular localities.

There are two facts which seem to point to the depth of the waters in which the stratified drift of northern Delaware was deposited. The first of these is the presence of stratified sands upon the top of Polly Drummond's hill, 250 feet above the Cretaceous plain. This elevation is well known as the highest point in the State, and therefore the highest point at which such deposits could have been made. The materials were well-washed reddish and yellowish quartzose sand, unassociated with pebbles, and the section seen showed the most eminent stratification running in a horizontal direction. The second fact is the occurrence of two hills of unstratified glacial detritus and bowlders three miles to the south, called respectively Iron and Chestnut Hills (see this Journal, Jan., 1883). These hills are no doubt piles of débris dropped from one or more ice-floats moving upon the surface of waters which covered the region. The highest of these elevations is 227 feet above the level of the Cretaceous plain upon which the hills rest.

Upon the very top of the highest elevation, the whole surface is strewn with enormous bowlders of dolerite, a few of which measure twenty-five feet in circumference. It is quite evident that so large bowlders could have been transported only by floating ice-rafts, while their present position upon the very summit of one of the hills was probably due to the fact that the ice-floats must have been carried upon the surface of water which was higher in level than the tops of the hills. But perhaps the most conclusive proof of all, in this latter connection, regarding the depth of the waters, is the slightly modifying action which in places this unstratified drift has undergone, for upon the very top in an excellent cutting, I saw in places a perfect arrangement of the materials, showing the slight modifying action of the water over the top of the hill.

The height of the Cretaceous plain at Newark, the level from which my elevations were measured, is 80 feet above mean tide; if then we should add to this 250 feet, the height of Polly Drummond's Hill, we shall have 330 feet as the least rise of the sea above its present level; which we must remember means nothing more than an equivalent depression of the land during the Champlain period. Such a depression of the land would have covered the entire peninsula with one sea or estuary connecting the Delaware with the Chesapeake. The waves of this estuary beating against the upturned gneissic and schistose rocks of the north would spread out upon its bottom the sands and gravels which overlie the clays. The cold currents from the north fed by the melting glacier would produce conditions unfavorable to marine life, and hence the absence of shells in this red sand. The total thinning out southward of the latter deposit is entirely characteristic of all sea-border

formations, and hence we are safe in attributing to it this origin. At this time the Archæan depressions had not yet been carved out, but merely a universal sea spread over the whole peninsula depositing the sands of Polly Drummond's Hill, while upon the surface of the waters, ice-rafts floated southward dropping the materials of Iron and Chestnut Hills, and scattering the bowlders found in various parts of New Castle County.

When at the close of the Champlain period, the land began to rise toward its present level a deep estuary was changed into a shallow one, the higher Archæan land rose out of water, and now began the erosion of the elevations and depressions of the north. The waters of the estuary to the south through increasing shallowness would become muddy, and would hold in suspension and transport materials washed from the Archæan hills, while these materials through gradual settling would form the argillaceous soil.

The gravel terraces found in various portions of eastern Pennsylvania, through the labors of the Second Geological Survey, causes Professor Lesley to draw the conclusion that the sea level stood even 1000 feet higher during the Champlain than now. Similar observations in New Jersey by Professor Cook point to a rise of the sea equal to 900 feet. As far as Delaware is concerned, we have direct evidence of a rise of at least 330 feet; but as the evidence was obtained from stratified materials at the highest altitudes in the State, it may be possible that the rise in sea level was as great as inferred by Professor Lesley.

Delaware College, April 2, 1883.

ART. XLVII.—*On the Western discharge of the flooded Connecticut, or that through the Farmington Valley to New Haven Bay;* by JAMES D. DANA.

THE discussion with regard to the flooded Connecticut requires for its completion a revision of the facts with respect to the Farmington valley discharge, presented in my paper of 1875.* It was there shown that the height of the flood from Northampton southward, as indicated by the terraces, was great enough for the waters to have passed the Hampton "divide" between Northampton and Westfield, and the Southwick, between Westfield and the Farmington valley; that they had a height of about 270 feet above mean tide at Simsbury (130 feet above low water in the river), and 223 feet at Southington (85 above low water); and that, from this latter place, while the rapidly

* On the Overflows of the flooded Connecticut, III, x, 438.

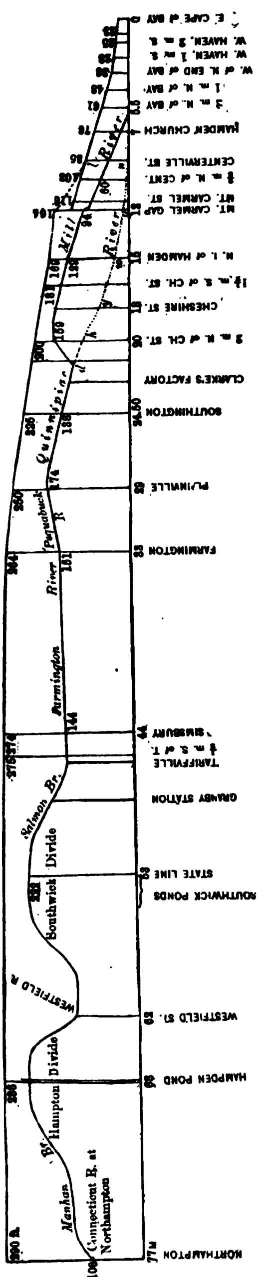
descending Quinnipiac valley gave the most obvious way for the waters to New Haven Bay and Long Island Sound (the mean pitch in the sixteen miles being over nine feet a mile), the level over the Cheshire region and along Mill River was low enough to have afforded a shallower passage-way, and one more directly southward, to the same bay. The Quinnipiac River where the stream turns eastward to leave the Farmington Valley, below Hough's Mills, is at the present time only 100 feet above mean tide, there being a fall of nearly forty feet from Southington; while the head of Mill River in Cheshire, about three miles distant to the southwest, is fifty-five to sixty feet higher; and hence the Quinnipiac was supposed at the time to have taken the most of the waters if not all.

The map of the Connecticut River region, in vol. xxiii, Plate 2 (1882), shows the country and its streams from Northampton along the Farmington Valley and the Quinnipiac and Mill Rivers to New Haven. For the convenience of the reader, the map of the two regions which was published in the paper of 1875 is reproduced as Plate 5 in this volume.

In order to complete a profile of the flood, it became necessary to make new measurements, and also to settle the rival claims of the two streams, the Mill and the Quinnipiac. Unexpectedly little Mill River was proved to have taken all the waters of the Farmington valley when the flood was at its height.

This fact was proved by (1) the continuation of the high terrace of the Southington region over the Cheshire region, along Mill River as well as the Quinnipiac, in spite of the lower position and offers of drainage of the Quinnipiac water-way; (2) the high water level (164 feet) indicated on the Mill River valley south of Cheshire at the Mount Carmel gap; (3) the cobble-stone coarseness of a large part of the stratified valley deposits from Southington southward over the Cheshire region and thence all the way down Mill River valley to New Haven Bay; and then, in contrast with these evidences of high and violent flood along the Mill River route, (4) the very low terrace on the Quinnipiac, as it enters the Meriden valley above Hanover Pond, and (5) the generally sandy nature of the terrace deposits in this part and to the southward along through Wallingford where the sands make barren sand-fields, and beyond to New Haven Bay.

It is plain that the Quinnipiac channel was closed by a dam, probably an ice-dam. The river now leaves the Farmington valley by a gorge that goes eastward through high sandstone hills, and after more than a mile in the gorge or cañon enters the Meriden valley. The gorge was easy of obstruction by



Section of the overflow flood of the Connecticut from Northampton to New Haven: the lower line, mean-tide level; the middle line, low-water level in the streams over the land that was covered by the flood; the upper line, the upper-terrace level and approximate height of flood. *d*, Hough's mills; *h*, head of Hanover Pond; *y*, Yalesville; *w*, Wallingford; *q*, Quinnipiac Factory; *n*, North Haven.

floating ice, and so the river lost its head. Below the gorge it had to begin anew, with waters from slopes about the latter region, receiving from its former source only what leaks in the dam let through, and hence the terrace also began anew, and was necessarily small. On the other hand to the west of the obstructed gorge, the Farmington flood kept on a straight course to Long Island Sound.

The accompanying profile of the river-flood from Northampton by the Farmington and Mill River valleys to New Haven exhibits the facts to the eye—though with a large exaggeration (nearly 160 times) in the height as compared with the length, an inch horizontal corresponding to twelve miles, and the vertical to 400 feet. The *upper line* shows the height, along the route, of the upper terrace, and thereby approximately that of the flood; starting at 290 feet above mean tide about Northampton, it passed the "divides" with a depth of more than fifty feet and ended at New Haven Bay with a height of about twenty-five feet above present mean tide. The *line next below* is that of low water in the streams. The *lowest* line is that of existing mean tide level; the figures under it give the distances measured along the valley from the east or Light-house Cape of New Haven Bay; and the lettering below, the names of the principal places along the

route where the observations registered were made, with their distances from this cape.*

I. *Section from Northampton along the Farmington, Quinnipiac, and Mill Rivers to New Haven and Long Island Sound.*

	Distance from Sound in miles.	Upper terrace above mean tide.	Low river level above mean tide.	Upper terrace above low river level.
Northampton	77	290	108	182
Hampden Pond	68	286		
Hampton Pl'n ("divide")	64	[249–256]	231	
Westfield	62		122·4	
½m. S. of Tariffville	45·5	275	143·5	131·5
Simsbury	44	274	144	130
Farmington	33	264	151	110
Plainville	29	250	174	76
SOUTHINGTON	24·50	225	138	87
2m. N. of Cheshire St.	20	200	159	41 to W.† / 104 to E.
1¼ m. S. of Cheshire St.	16·50	181	142	39
N. line of Hamden	15	169	129	40
Mt. Carmel gap	12	164	94·5 to 82·5	69·5
Mt. Carmel Station	11·50	118·5		36
¾m. N. of Centerville	10	103	60	43
Centerville Station	8·75	88	38	47
Hamden M. E. Church	7	76		50?
2m. N. of N. H. Bay	5·5	61	tide level	
1m. N. of N. H. Bay	4·5	48		
W. of N. end of Bay (N.)	3·5	38		
W. Haven, 1m. S. of N. end of Bay	2·5	28		
W. Haven, 2m. S. of N. end of Bay	1·5	25		
W. Haven, 2½m. S. of N. end of Bay	1·0	23		
Lighthouse Point E. Cape of Bay	0			

* The height of the terrace at Hampden Pond is from a valuable paper by Mr. J. S. Diller, published in this Journal in 1877, giving careful measurements of the terraces about Westfield and the "divides" north and south. He states that on Westfield River, sixteen miles west of the village, the highest river terrace is 289 feet above sea-level; and that, allowing for the most probable slope in the stream, the height over Westville village is probably not less than 280 feet. (This Journal, III, xiii (1877), 262.)

The heights of the terraces south are from my measurements, for which I used as a base the levels of the New Haven and Northampton railroad, received from the engineer of the road. These levels above mean tide are as follows: at Mt. Carmel Station and Gap, 132 feet; at N. line of Hamden, 135; Cheshire Station, 165; 2 m. N. of ibid., 163; Hitchcock's, 164·5; Southington, 145·76; Plainville, 187·5; Farmington, 241; Allen's Station, 277; Avon, 201; Simsbury, 164·25; surface of Southwick Ponds, 222·11; surface of Hampden Pond, 248·27.

† "To W." signifies above the level of low water on the Cheshire or *western* side, and "to E." above the same on the Quinnipiac or *eastern* side, just below Hough's mills.

The heights are also given in the preceding table, in which the first column contains the distances from the east or Lighthouse Cape of New Haven Bay; the *second*, the heights of the upper terrace; the *third*, those of low-river levels, above mean tide; and the *fourth*, the height of the upper terrace above the low-river levels.

The above profile shows also, by means of a dotted line (*d*, *n*) the descent by the course of the Quinnipiac valley. On this stream tide-level is reached at North Haven.

A second table is here added, to present in figures the heights of the terrace-deposits and river from Southington, southeastward and southward, by this latter route.

II. *Section from Southington along the Quinnipiac to Fair Haven (E. of New Haven).**

	Distance from Sound (northings) in miles.	Upper terrace above mean tide.	Low river level above mean tide.	Upper terrace above low river level.
SOUTHINGTON	25·25	225	138	87
1·6 m. S. of Southington, at Atwater's factory	23·60	207	129	78
2·05m. S. of Southington, at Clarke's factory	23·20		120	
¼m. N. of Hough's mills	20·75	200	102	98
Hough's mills below dam	20·25	200	96–95	104–105
Head of Hanover Pond	19·75	105	86	19
Foot of Hanover dam	19·75	105	69	36
Ab. Yalesville, Sanford's factory	18·33	96	52·5	43·5
Yalesville, Parker's fact.	17·67	93	49	44
Wallingford	15	76	13	63
Quinnipiac factory	13·25	68	5	63
				Ab. mean tide.
North Haven	10·25	60	0	60
¼m. N. of Montowese R. R. station	7·75	52	0	52
Junction Hartford and Air Line R. R.	5	49	0	47
Fair Haven R. R. and Perkins St. crossing	4·5	43	0	43
E. Cape of Bay	0			

* The heights of the terraces here given were obtained by leveling from the surfaces of the mill-ponds as a base, the heights of the mill-ponds having been determined from the heights of the dams and the fall of the river between them, obligingly obtained for me by Mr. S. C. Pierson, Civil Engineer at Meriden. The heights of low water are heights to the base of the dams. The heights of these dams are as follows, commencing to the south: the Quinnipiac, on the south boundary of Wallingford, 6 feet; the lower dam at Wallingford (Wallace, Simpson & Co.), 10 feet, the upper, or Community dam. 8 feet; below Yalesville (A. J. Mix's), 10; at Yalesville (Parker's), 10; near Yalesville R. R. station (Sanford), 7; Hanover, 17; Oregon dam (in the gorge between Hanover Pond and Hough's mills, but now destroyed), 6; Hough's mills, 6 feet. Hanover Pond was proved by Mr. Pierson, by leveling from Meriden, to have a height above mean tide of 86 feet, the height of the track of the railroad at Meriden station being 124·63 feet.

The profile and the tables with the other observed facts make manifest:

First. The fact of the Quinnipiac dam, as already explained; the *first* table showing a gradual decline in the heights of the upper-terrace level from Southington through Cheshire; and the *second*, the continuation of the high-level Quinnipiac terrace of Southington to Hough's Mills, or 4½ miles, where the terrace has a height of 200 feet and is one and the same with that of Mill River; then a drop down of 95 feet, the terrace just above the head of Hanover Pond having a height of only 105 feet above mean tide, and but 19 feet above low water in the stream.*

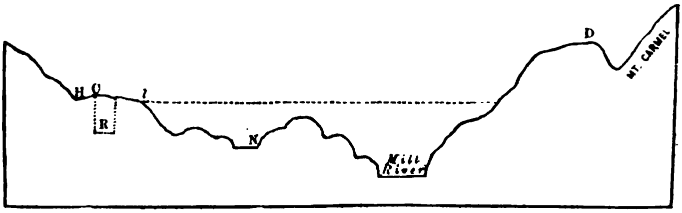
(2.) *Secondly, the existence of a dam at the Mt. Carmel gap and of a sluice-way at its western angle.*—The water-level at the gap, as the profile and tables exhibit, was at least 164 feet above mean tide. From this level there was an abrupt plunge or water-fall, of about 45 feet; for the highest terrace of the flat region directly south is but 118 to 118½ feet, which terrace bears evidence of being the upper in the valley, in that it is continued on as the upper, with gradual slope, to New Haven Bay. The water-fall is indicated in the section, page 442, under the number 164.

The height of the terrace two miles north of the gap is some indication as to flood-level at the gap. But direct evidence is afforded by deposits of very coarse gravel, partly cross-bedded, near the top and under the lea of the western trap ledge of the gap; and also (2) by the continuation of these deposits southward, many of the stones of which for the first mile are one to three feet in diameter, all well smoothed and *none scratched*; and (3) by the existence of remains of a great well-smoothed trough or sluice-way, about 30 feet wide, in the sandstone, which was the work evidently of a violent torrent, several long oblique recesses on its sides, one to three feet broad, being marks of its *revolving* flow; the smoothed surfaces are nowhere scratched, and in this and other ways show that they are not of glacier origin.

The accompanying figure is a profile of the gap, with the height exaggerated only two times. Mt. Carmel (on the east) is an east-and-west ridge, chiefly of trap, 739 feet in greatest height above mean tide. It is the eastern portion of a range

* Going southward from Hanover Pond (southwest of Meriden), the terraces of the Quinnipiac increase in height and become between Wallingford and Fair Haven 40 to 52 feet; this increase was due to tributary waters from the direction of Meriden, and the divide between Hartford and Meriden. In my paper of 1875 I point out the fact that the Connecticut flood waters overtopped this divide. The divide has a height of 185 feet above mean tide, which was 20 or 25 feet below the level of the flood at Hartford: and the terrace topping the divide has a height of about 20 feet.

of trap and sandstone which continues westward to the West Rock trap range. The gap is about 250 yards wide; but it is



partly obstructed by ledges, and Mill River occupies only 100 feet of its breadth. The waters of the sluice-way flowed out (at H) west of the summit of the western of these ledges (C); the lowest level over which at H is now 164 feet. The stratified gravel referred to as under the lea of this ledge (visible from the railroad cut R) has a height of about 152 feet; and the upper limit now visible of the excavated trough or sluice-way near the Mt. Carmel station, half a mile south of the gap, has a height of 145 feet. This trough or sluice-way in the sandstone was uncovered in grading for a new lay-out of the railroad, it offering the lowest level for the track. It can be traced along the course of the railroad for 200 yards below the station; it then passes to the westward of the road and becomes the head of a partly cobble-stone paved valley whose stream joins Mill River at Centreville (see section). The sluice-way torrent must finally have worn away part of the east side of the trough and so made a passage into Mill River valley. The height of the trap at D above mean tide is about 240 feet.

(3.) *The slope of the flood-level was widely different above and below Farmington.*—The slope of the terrace (or of flood-level) for the first 33 miles, that is, from Northampton to Simsbury (*Sb* on plate 5) was only 6 *inches* a mile; and for the first 44 miles, or to Farmington, about 7 *inches*; while southward, from Farmington to a point 2 miles north of Cheshire, where the high land of Cheshire begins, it was about 5 *feet* a mile; from the latter place to the Mt. Carmel gap, about the same; and from Mt. Carmel village to New Haven Bay, 10 *feet* a mile. A reason for this change in slope at Farmington exists in the fact that the flooded Farmington River here entered the valley from an extensive region to the northwest, and the Pequabuck added waters from the west; the two draining a high portion of western New England about 200 square miles in area. The flood consequently received its greatest accessions at this point; and the waters were so rapidly supplied that the slope northward was diminished and that southward increased. On the *west* side of the valley to the north of Farmington station, the

upper terrace is well displayed, and especially along by Simsbury and for a mile and more to the north, where it is 130 feet above low water in the river and quite wide. But on the *east* side of the valley the terrace above Farmington is for the most small, no large stream, capable of affording transported material, flowing from that direction because of the nearness of the trap range.

Further, the terrace deposits are greatly coarser south of the Farmington River entrance than to the north of it. To the north they are chiefly of sand with fine or coarsish gravel above; but near the Farmington station and south of it through Southington and beyond, the deposits are remarkable for their coarseness, as above stated.

(4.) *A great change in the old hydraulic conditions.*—Before the era of the flood the drainage south of Northampton, supposing the land to have had nearly its modern slopes, was as follows: for a dozen miles *northward;* then *eastward*, in Westfield river; for the next three miles, the first half *northward* and the second *southward;* then for 17 miles *northward*, by the Farmington River and the Pequabuck; finally, for the rest of the distance to New Haven, 25 miles, *southward*, excepting a break of two miles between the Quinnipiac and the head of Mill River. But, in the era of the flood, this whole uneven region of many slopes, was under one continuously sloping water-plane, having a fall, if reckoned on the basis of the present slope of the land, of 290 feet in 77 miles. The northward-flowing streams and the streams at equilibrium as to erosion and deposition, or at "base level," if any there were, were merged with the southward flowing streams into one great southward hurrying flood, the depth exceeding 120 feet at maximum height and 40 feet where shallowest. It is an example, though on an extreme scale, of the kind of change over a region which a modern flood may produce in hydraulic conditions and in the activity of fluvial forces.

The flood produced other effects over the New Haven region south of the Mt. Carmel gap, which are of much geological interest. These will make the subject of another article.

A few words only are here added as to the bearing of the facts reviewed on the question with regard to *the slope of the land in the era of the flood.*

In my paper on "flood of the Connecticut River valley," in volume xxiii of this Journal (1882), it is apparently proved that the southward slope of the land was much less during the flood than now—the calculated mean diminution from the Sound to Springfield being one foot a mile, and from Springfield to Haverhill 2½ feet a mile. Hence we should expect to find evidence of some corresponding difference of slope

to the westward of the Connecticut over the Farmington valley. But it follows from the facts presented that the diminution in slope between Farmington and Northampton *could not have been* 1 *foot a mile without producing a current northward*, and so making Northampton the place of discharge instead of outflow; for it would have given a mean slope in that direction of 5 to 6 inches a mile. Mr. Diller, in his paper on the Westfield region, mentions as evidence of a *southward* flow from Northampton that the terrace material over the Hampton "divide" diminishes in coarseness southward, and that it contains a great abundance of fragments or pebbles of trap which had their only source to the northward in the northwest angle of Mount Tom. Moreover, since the fall from Northampton to New Haven at maximum flood was in any case over 200 feet, it is impossible, without a most improbable inflow, that the waters should have been so piled up at Farmington as to flow in opposite directions. We have to conclude, therefore, that the diminution in slope southward must have been less than 7 inches a mile. No clay deposits are known to occur in the Farmington terrace deposits, and no other evidence of lacustrine conditions.

South of Farmington the coarse deposits may have been made with the slope diminished a foot or more.

In the Meriden valley, where the terrace formation consists mainly of sand, the present pitch of the terrace-level is much too great for such depositions. From Hanover Pond to North Haven the mean slope, according to Table II, is $4\frac{1}{2}$ feet a mile; and about 4 feet, from the same point to Fair Haven.

ART. LXVIII.—*Results of some experiments made to determine the variations in length of certain bars at the temperature of melting ice;* by R. S. WOODWARD, E. S. WHEELER, A. R. FLINT and W. VOIGT.

THE precision attained of late in comparisons of standards of length, and in geodetic work dependent on such standards, has rendered the question whether a given bar can have differing lengths at the same temperature an important one. In order to obtain some data bearing directly on this question the authors of this paper have undertaken on their own account a series of experiments with bars of various metals.

For the purpose of making these experiments the following apparatus has been provided:

1st. Two micrometer-microscopes designated F and W respectively. The optical work on these is by Bausch and Lomb of Rochester, N. Y., and the micrometers and stands were made

by L. Wohnlich of Detroit, Mich. The magnifying power of each microscope as used in the experiments is about thirty diameters. They are provided with leveling and clamp screws, can be revolved completely in azimuth (thus permitting the determination of the lines of collimation) and have detached levels with which they may be made vertical. They are mounted one meter apart on an oak beam. This beam is $1{\cdot}8^{m}$ long, 26^{cm} wide and 5^{cm} deep. Its ends are supported on heavy stone piers about 1^{m} high

2d. Two steel meter-bars. They are $1{\cdot}04^{m}$ long and 16^{mm} square in cross-section. They were made from ordinary Jessup steel in the summer of 1881. The upper half of either bar at each end is cut away for a distance of 3^{cm}, so that the graduations cross the neutral axis. They were graduated and their lengths and expansions were determined by Professor W. A. Rogers of Cambridge, Mass. They are designated S_1 and S_2 respectively.

3d. One zinc bar, which is $1{\cdot}03^{m}$ long and 27^{mm} square in cross-section. It was cast in the summer of 1881. The ordinary zinc of commerce was used, and the bar was cast in a vertical position. About $0{\cdot}2^{m}$ of the upper end of the casting was cut off. The top half of the bar at each end is cut away for a distance of 2^{cm}, so that the graduations cross the neutral axis. This bar was also graduated and its length and expansion were determined by Professor Rogers. It is designated Z_1.

4th. Two glass meters. They are of French plate, $1{\cdot}02^{m}$ long, 8^{mm} thick and 51^{mm} deep. Half the depth of either bar at each end is cut away for a distance of 2^{cm}, and the graduations cross the neutral axis. They are designated G_1 and G_2 respectively.

5th. One copper meter. It was cast in February, 1883, and is $1{\cdot}02^{m}$ long, 20^{mm} wide and 22^{mm} deep. Its graduations cross the neutral axis. It is designated C_1.

6th. One brass meter. It was cast in February, 1883, and is composed of ten parts of copper to three of zinc. It is of the same form and dimensions as the copper meter. It is designated B_1.

Comparisons are made in the following manner:

The bars to be compared are each placed in a wooden box $1{\cdot}1^{m}$ long, $0{\cdot}1^{m}$ wide and $0{\cdot}1^{m}$ deep. The bars are supported in their boxes at two points distant about one-fourth and three-fourths the length of the bar from either end. The boxes are filled with finely powdered ice so as to completely surround the bars except at small spaces near the graduations. The boxes are placed on a shelf under the microscopes. Each box has three leveling screws which rest on plates of glass, so that the bars may be easily adjusted to any requisite position. The

graduated surfaces of the bars are brought into a horizontal plane within 1′ by means of a long striding level. The microscopes are focused on the graduations at the ends of a level bar, made vertical within 1′ and their readings on the lines of collimation determined. Micrometer readings are then made on the bars alternately, these readings being near the lines of collimation. The values of the micrometer screws are determined at intervals by reading on spaces of known value. No account has been taken of the periodic errors of the screws, since an investigation has shown these errors to be insignificant in comparison with other errors incident to the experiments.

The plan adopted in making the experiments is this: Taking one of the steel bars as a standard, several sets of comparisons are made with another bar. The latter bar is then put into water and left there while the water is heated gradually to the boiling point. It is then taken out of the water and cooled down gradually to the melting point of ice, when several sets of comparisons are again made with the standard. Afterwards the bar is cooled gradually to $-6°$ or $-8°$ F., warmed gradually to the melting point of ice and again compared with the standard.

The following table gives the comparisons of the steel meter S_1 and the zinc meter Z_1, both bars while under comparison being closely packed in melting ice. The micrometer readings are expressed in revolutions of the screws. One revolution of $F=92{\cdot}1^{\mu}$ and one revolution of $W=95{\cdot}3^{\mu}$, the symbol μ meaning *microns* or millionths of a meter. The revolutions increase in the direction $F-W$; so that if F_1 and W_1 are the readings on Z_1 and F_2 and W_2 the readings on S_1, we have from these readings

$$Z_1-S_1=(F_1-F_2)\,92{\cdot}1^{\mu}-(W_1-W_2)\,95{\cdot}3^{\mu}$$

Comparisons of S_1 *and* Z_1 *at the temperature of melting ice.*

Date.	Time.	Bar.	Micro-readings. F	Micro-readings. W	Observer.	Remarks.
1883.						
Jan. 28	11.45 A.M.	S_1	28·059	24·162	A. R. F.	Both bars packed in ice ten minutes before readings on them were made.
			058	462	and	
			061	463	R. S. W.	
			060	458		
	51	Z_1	28·044	24·371		
			050	374		
			039	370		
			048	374		
	56	S_1	28·010	24·387		
			27·998	334		
			994	339		
			999	341		
	59	Z_1	27·943	24·260		
			950	262		
			939	257		
			950	257		
	12.04 P.M.	S_1	27·697	24·243	E. S. W.	
			701	251	and	
			680	238	W. V.	
			688	259		
	09	Z_1	27·861	24·190		
			861	183		
			857	176		
			848	176		
	13	S_1	27·690	24·189		
			686	186		
			687	189		
			688	186		
	17	Z_1	27·689	24·018		
			692	020		
			682	018		
			679	020		
Jan. 29	8.27	S_1	28·112	25·088	A. R. F.	Both bars fully packed in ice at 8.10 P. M.
	31	Z_1	153	031	and	
	35	S_1	165	134	E. S. W.	Temperature of comparing-room 56° F.
	38	Z_1	002	24·855		
	42	S_1	010	949		
	45	Z_1	27·988	846		
	48	S_1	935	909		
	51	Z_1	28·020	913		
	55	S_1	27·918	905		
	58	Z_1	892	782		
	9.01	S_1	998	962		
Jan. 30	7.23	S_1	28·208	121	E. S. W.	Both bars were fully covered with ice at 7.05 P. M.
	30	Z_1	313	099		
	36	S_1	273	164		Temperature in comparing-room 55° F.
	40	Z_1	262	066		
	45	S_1	124	039	R. S. W.	
	49	Z_1	430	241		
	55	S_1	161	102		
	59	Z_1	509	332		
	8.03	S_1	034	23·971	E. S. W.	
	06	Z_1	161	24·010		
	12	S_1	27·808	23·822	R. S. W.	
	27	Z_1	890	771		

Comparisons of S_1 *and* Z_1 *at the temperature of melting ice—con'd.*

Date.	Time.	Bar.	Micro-readings. F	Micro-readings. W	Observer.	Remarks.
1883. Jan. 31	7.57 P.M.	S_1	27·926	23·830	E. S. W.	Steel meter was fully packed in ice at 6.55 P. M., and zinc meter at 7·08. The temperature of the ice (granulated snow brought in from out doors at 6.55 P. M.) was found to be below the melting point. Hence both boxes were placed near a furnace fire until the snow would not adhere to the bars. Temperature of comparing-room 50° F.
	8.05	Z_1	915	700		
	14	S_1	749	695		
	17	Z_1	556	411		
	22	S_1	716	660		
	26	Z_1	658	504		
	30	S_1	28·272	24·217	R. S. W.	
	35	Z_1	368	232		
	40	S_1	361	324		
	50	Z_1	321	177		
	55	S_1	064	064		
	59	Z_1	077	23·956		
	9.02	S_1	27·997	994		At 4.30 P. M. Z_1 was put inside and raised about ¾ inch from bottom of tin receiver. The latter was put on a stove and filled with water at temperature 41° F. Water was 1 inch deep over bar. Fire was started under receiver at 4.50. Bar was heated to about 208° F. and remained at that temperature about 15 minutes.
Feb. 2	8.55	S_1	28·800	24·223	E. S. W.	
	9.02	Z_1	29·486	23·310		
	09	S_1	27·940	418		
	13	Z_1	28·661	22·541		
	24	S_1	208	23·680	R. S. W.	
	27	Z_1	29·069	22·950		Z_1 was taken out of water at 8.10 and packed in ice at 8.45.
	30	S_1	27·909	23·395		
	36	Z_1	28·475	22·406		S_1 was packed in ice at 8.30.
Feb. 3	11.09 A.M.	S_1	27·748	23·128		Both bars remained packed in ice during night of Feb. 2d and 3d. At 8.30 A. M. they were repacked with additional ice and remained so until readings began.
	17	Z_1	29·768	870		
	22	Z_1	410	508		
	26	S_1	28·622	993		
	30	S_1	607	970		
	36	Z_1	29·068	197		
	40	Z_1	28·918	059		
	45	S_1	100	490		
	49	S_1	27·850	252		
	55	Z_1	28·463	22·619		
Feb. 3	7.29 P.M.	S_1	28·361	23·979	E. S. W.	Both bars have been kept packed in ice since 11.55 A. M.
	38	Z_1	858	300		
	44	Z_1	29·123	552		
	49	S_1	28·502	24·145		
	58	S_1	837	472	R. S. W.	
	8.03	Z_1	29·474	23·910		
	10	Z_1	691	24·176		
	15	S_1	009	664		
	20	S_1	28·748	·436		
	23	Z_1	29·287	23·749		
Feb. 4	10.53 A.M.	S_1	28·268	24·115	E. S. W.	Both bars have remained in ice all night.
	11.01	Z_1	788	23·552		
	06	Z_1	29·229	970		
	09	S_1	28·178	24·024		
	13	S_1	474	290	R. S. W.	
	17	Z_1	834	23·556		
	24	Z_1	29·041	739		
	27	S_1	28·358	24·189		
	32	S_1	567	405		
	35	Z_1	29·028	23·760		
Feb. 5	8.04 P.M.	Z_1	142	970		Zinc bar has remained in melting ice constantly.
	07	S_1	28·532	24·460		
	11	S_1	619	540		
	14	Z_1	801	23·662		

Comparisons of S_1 *and* Z_1 *at the temperature of melting ice—con'd.*

Date.	Time.	Bar.	Micro-readings. F	Micro-readings. W	Observer.	Remarks.
1883.						
Feb. 5	8.18 P.M.	Z_1	29·135	23·980	E. S. W.	Zinc bar has remained in melting ice constantly.
	21	S_1	28·406	24·339		
	24	S_1	780	702		
	29	Z_1	29·196	070		
	34	Z_1	383	268		
	37	S_1	198	25·118		
	46	S_1	067	005	R. S. W.	
	50	Z_1	464	24·280		
	57	Z_1	345	210		
	9.00	S_1	28·802	752		
Feb. 6	7.23	S_1	211	23·866	E. S. W.	Zinc bar has remained packed in ice since last evening.
	35	Z_1	618	221		
	45	Z_1	29·081	656		Steel bar was packed in ice about 6.45 P. M.
	52	S_1	27·966	634		
	8.03	S_1	28·004	685	R. S. W.	Temperature of air in comparing-room 44° F.
	11	Z_1	517	135		
	18	Z_1	435	069		
	21	S_1	27·710	433		
Feb. 7	7.46	S_1	28·533	24·214	E. S. W.	Both bars have been unpacked and exposed to the air of the comparing-room during the past 24 hours.
	8.03	Z_1	29·218	23·782		
	10	Z_1	28·618	229		
	17	S_1	27·994	646		
	23	S_1	28·369	24·019	R. S. W.	Temperature of air in comparing-room 44° F.
	26	Z_1	815	23·516		
	35	Z_1	865	565		Bars were packed in ice about 7.20 P. M.
	40	S_1	446	24·119		
	43	S_1	753	425	E. S. W.	
	47	Z_1	29·404	062		
Feb. 8	9.28	S_1	28·350	110	R. S. W.	Both bars have been out of the ice during the past 24 hours.
	35	Z_1	727	23·428		
	38	Z_1	764	453		They were packed in ice about 8.00 P. M.
	42	S_1	260	979		
	45	S_1	388	24·111		Temperature of air in comparing-room 45° F.
	48	Z_1	952	23·610		
	52	Z_1	967	629		
	55	S_1	444	24·148		
Feb. 9	5.18	S_1	438	220	E. S. W.	Both bars have been out of the ice since 10.00 P. M. Feb. 8th.
	23	Z_1	29·098	23·778		
	28	Z_1	176	861		Both bars were taken out of the ice at 5.55 P. M.
	32	S_1	28·626	24·394		
	38	S_1	717	504	R. S. W.	
	40	Z_1	29·420	114		
	48	Z_1	454	163		
	50	S_1	730	488		
Feb. 10	11.41 A.M.	Z_1	28·330	249		At 9.30 P. M. Feb. 9th, the zinc bar was placed in its receiver, taken out doors and left out all night. At 6.45 A. M. Feb. 10th, a thermometer which had lain alongside the zinc bar during the night read —8° F. At 7.30 the zinc bar was packed in granulated snow and brought into the comparing-room in which the temperature of the air was 45° F.
	45	S_1	631	284		
	50	S_1	341	016		
	55	Z_1	407	308		
	12.01	Z_1	372	287		
	04	S_1	498	181		
	09	S_1	796	494		The steel bar was packed in ice about 9.00 A. M.
	14	Z_1	744	639		
	19	Z_1	410	309	E. S. W.	
	21	S_1	410	101		

Comparisons of S_1 *and* Z_1 *at the temperature of melting ice—con'd.*

Date.	Time.	Bar.	Micro-readings.		Observer.	Remarks.
			F	W		
1883.						
Feb. 10	7.59 P. M.	S_1	28·374	23·979	E. S. W.	Both bars have remained packed in ice since 12.21 P. M.
	8.12	Z_1	345	24·126		
	21	Z_1	028	23·825		
	25	S_1	052	649		
	35	S_1	275	901	R. S. W.	
	38	Z_1	684	24·507		
	50	Z_1	398	212		
	54	S_1	564	179		
Feb. 11	10.42 A. M.	S_1	526	24·192	E. S. W.	Zinc meter has remained packed in ice during past night.
	49	Z_1	591	460		
	58	Z_1	231	100		Steel bar was packed in ice about 10.00 A. M.
	11.03	S_1	283	23·928		
	08	S_1	486	24·139	R. S. W.	
	13	Z_1	577	448		
	23	Z_1	859	717		
	26	S_1	833	493		
Feb. 12	8.00 P. M.	S_1	126	090		Both bars were packed in ice at 7.30 P. M.
	03	Z_1	006	013		
	08	Z_1	259	267		
	11	S_1	273	242		
	13	S_1	122	080	E. S. W.	
	15	Z_1	208	248		
	21	Z_1	208	258		
	24	S_1	074	063		
Feb. 13	8.19	S_1	272	345		The zinc bar was taken out of the ice at 8.30 P. M. Feb. 12th and left in comparing-room until 4.00 P. M. to-day. It was then taken into a room where the temperature was about 70° F. and remained there until 7.45 P. M. It was fully packed in ice at 7.55.
	27	Z_1	270	123		
	36	Z_1	27·990	23·850		
	39	S_1	28·386	24·446		
	42	S_1	429	518	R. S. W.	
	45	Z_1	528	388		Temperature of air in comparing-room 50° F.
	47	Z_1	534	383		Steel bar was fully packed in ice at 8.00 P. M.
	50	S_1	340	421		

The foregoing include all the comparisons which have thus far been made of the zinc and steel bars.

The mean differences in length of the two bars for the various sets of comparisons are given in the following table. Their probable errors are derived from the discrepancies between the mean and individual differences resulting from successive comparisons in a set.

Mean differences of Zinc and Steel bars.

Date.	$Z_1 - S_1$	Remarks.
1883.	μ μ	
Jan. 28 A. M.	$+ 12{\cdot}2 \pm 2{\cdot}8$	Before heating Z_1.
29 P. M.	$+ 9{\cdot}0 \pm 0{\cdot}5$	
30	$+ 9{\cdot}9 \pm 0{\cdot}5$	
31	$+ 10{\cdot}4 \pm 0{\cdot}4$	
Feb. 2	$+149{\cdot}1 \pm 0{\cdot}7$	After heating Z_1 to 208° F.
3 A. M.	$+116{\cdot}6 \pm 0{\cdot}4$	Z_1 remained constantly in melting
3 P. M.	$+112{\cdot}3 \pm 0{\cdot}8$	ice from 8.45 P. M. Feb. 2d to 8.21
4 A. M.	$+103\ 3 \pm 0{\cdot}5$	P. M. Feb. 6th.
5 P. M.	$+100{\cdot}1 \pm 1{\cdot}0$	
6	$+100{\cdot}4 \pm 0{\cdot}4$	
7	$+ 95{\cdot}3 \pm 1{\cdot}8$	
8	$+ 98{\cdot}2 \pm 0{\cdot}5$	
9	$+101{\cdot}0 \pm 0{\cdot}8$	
10 A. M.	$- 21{\cdot}2 \pm 0{\cdot}7$	After cooling Z_1 to about $-8°$ F.
10 P. M.	$- 18{\cdot}5 \pm 0{\cdot}5$	Z_1 was in melting ice from morn-
11 A. M.	$- 20{\cdot}1 \pm 0{\cdot}4$	ing of Feb. 10th to evening of
12 P. M.	$- 5{\cdot}5 \pm 0{\cdot}7$	Feb. 11th.
13	$+ 21{\cdot}1 \pm 0{\cdot}2$	After heating Z_1 to about 70° F.

As indicated by the probable error of the mean difference, the comparisons of January 28th showed larger residuals than any subsequent set of comparisons. The comparisons of this date were the first made, and some unusual error may have been committed through lack of familiarity with the apparatus, though the observers are not aware that such was the case. Before packing it in ice on January 28th, the zinc bar had been for many months warmer than 32° F.

The close agreement of the mean differences for the first four dates may possibly result from the fact that the temperature of the comparing-room had varied for several days previous to the comparisons but little from 55° F., so that the bar was subjected to essentially the same conditions each day; i. e. just previous to each set of these comparisons Z_1 had fallen from about 55° F. to the temperature of melting ice.

The characteristic results obtained may be stated as follows:

1st. The temperature of the zinc meter was raised to 208° F. and then lowered to the temperature of melting ice. This increased its length at first 139^{μ} over its initial length. The bar was kept constantly in melting ice for four days, during which time it shortened 39^{μ}, leaving it still 90^{μ} longer than its initial length. Exposure to the air of the comparing-room (temperature about 45° F.) during the intervals between comparisons for the three days following, produced no material change in the length of the bar.

2d. The bar was cooled in the open air to about $-8°$ F. and then warmed to the temperature of melting ice. This dimin-

ished its length to 30^{μ} less than its initial length. The bar was kept constantly in melting ice for one and a half days, during which time no marked change in length occurred; but exposure to the air of the comparing-room for an interval of one day was followed by an increase of 15^{μ} in the bar's length, leaving it still 15^{μ} shorter than its initial length.

3d. The bar was exposed to an air temperature of about 70° F. for four hours and then cooled to the temperature of melting ice. This increased its length 26^{μ} over the length it had on the previous day, leaving it 11^{μ} longer than its initial length.

4th. The total range in temperature to which the bar was subjected was about 216° F. The total range in length of the bar at the temperature of melting ice was 169^{μ}.

In the comparisons of the steel, copper and brass meters with the steel standard, each bar except the standard was subjected to a temperature-range whose limits were approximately 212° F. and −6° F., the former temperature being secured by means of boiling water and the latter by means of a mixture of snow and salt. For the comparisons of the two steel meters S_1 and S_2 the latter was taken as the standard. For the comparisons of the copper meter C_1 and the brass meter B_{11}, S_1 was used as a standard. In order to prevent any serious bending of the copper bar it was laid on the steel bar S_2 and kept in contact with the latter throughout the period of the comparisons. The results of the comparisons of these bars are given in the following tables. Each result is a mean derived from four to ten independent comparisons. It will be remembered that differences in length were measured only after the bars under comparison had been for some time closely packed in melting ice.

Differences in Length of the Steel Meters.

Date, 1883.	S_2—S_1	Mean.	Remarks.
	μ	μ	
February 12	+11·0		
" 13	+ 9·6	+ 9·9	Before heating S_1
" 14	+ 9·0		
" 15	+ 9·9		
" 16	+10·1	+10·0	After heating S_1 to near 212° F.
" 18	+ 9·9		
" 23	+ 9·2		
" 25	+12·1	+10·9	After cooling S_1 to near −6° F.
" 26	+12·1		
" 26	+10·4		

Differences in Length of Steel and Copper Meters.

Date, 1883.		$S_1—C_1$	Mean.	Remarks.
		μ		
March	4	+43·7		
"	4	+50·5	μ	
"	5	+45·2	+47·1	Before heating C_1
"	5	+47·5		
"	6	+48·8		
"	7	+45·1		
"	9	+47·4	+47·9	After heating C_1 to near 212° F.
"	9	+51·4		
"	10	+47·7		
"	10	+45·6		
"	11	+47·9	+46·2	After cooling C_1 to near -6° F.
"	12	+45·6		

Differences in Length of Steel and Brass Meters.

Date, 1883.		$S_1—B_1$	Mean.	Remarks.
		μ		
March	10	+40·1		
"	11	+36·7	μ	
"	12	+36·1	+37·2	Before heating B_1
"	13	+36·0		
"	13	+34·0		
"	14	+36·7	+35·8	After heating B_1 to near 212° F.
"	15	+36·8		
"	20	+38·4		
"	21	+41·7	+39·6	After cooling B_1 to near -6° F.
"	23	+38·6		

The probable error of a single difference of length in the above tables may be derived preferably from the formula

$$0{\cdot}6745\sqrt{\frac{[vv]}{m-n}},$$

in which m is the whole number of results, n the number of groups of comparisons and $[vv]$ the sum of the squares of the discrepancies between the mean and individual results for the several groups. Including the results for the glass bars given below, this probable error is found to be $\pm 1^{\mu}{\cdot}3$.

The means of the respective groups of comparisons of the steel, copper and brass meters with the standard, do not differ enough to indicate certainly that any change of length (at the temperature of melting ice) was produced by the heating and cooling process, although the brass bar was apparently lengthened by heating and shortened by cooling it. The difference between the mean results for the brass bar after heating and after cooling it, viz: $3^{\mu}{\cdot}8$, though a measurable quantity is quite within the range which might be inferred from the above probable error.

For the comparisons of the glass meters G_1 and G_2, the steel meter S_1 was used also as a standard, and the same program was followed as with the other bars. By accident, however, G_1 was broken just subsequent to the second set of comparisons after heating it. The results of these comparisons are given in the following tables.

Differences in Length of Steel and Glass Meters.

Date, 1883.	G_1-S_1	Mean.	Remarks.
	μ	μ	
February 20	+154·1		
" 21	+154·9	+154·9	Before heating G_1
" 21	+155·8		
" 21	+159·1	+158·5	After heating G_1 to near 212° F.
" 22	+158·0		

Differences in Length of Steel and Glass Meters.

Date, 1883.	S_1-G_2	Mean.	Remarks.
	μ	μ	
March 15	+40·8		
" 16	+43·5	+41·0	Before heating G_2
" 16	+41·3		
" 17	+38·4		
" 17	+38·2		
" 18	+37·8	+38·2	After heating G_2 to near 212° F.
" 19	+39.3		
" 20	+39·4		
" 21	+36·8	+38·1	After cooling G_2 to near −6° F.
" 23	+38·1		

The means of the groups of results before and after heating the glass meters indicate that each bar was slightly lengthened (at the temperature of melting ice) by the heating, the quantity being $3^\mu{\cdot}6$ for G_1 and $2^\mu{\cdot}8$ for G_2. Although these quantities are within the range indicated by their probable errors, the fact that they agree so closely renders it somewhat probable that the heating process did produce a set in each bar. A much larger set might have been expected, as the opinion seems to be quite general that glass after being heated to temperatures as high as 212° F. does not speedily return to the dimensions it had, before being heated, at temperatures lower than 212° F. This opinion, however, appears to be based on experience with mercurial thermometers, in which a change of 0°·5 in the position of the freezing-point is not uncommon after the bulb has been heated to 212° F. Since the coëfficient of the cubical expansion of mercury is about $\frac{1}{10000}$ per degree F., a change of 0°·5 F. in the position of the freezing-point of a thermometer would correspond to a linear change of $\frac{1}{60000}$, or to $16^\mu{\cdot}7$ in the length of a meter. If, as indicated

by our experiments, some kinds of glass possess the property in question only in a very small degree, it would be interesting to know whether the change in the position of the freezing-point so uniformly and frequently so markedly manifested in thermometers is really due wholly to a temporary change in the dimensions of the bulb, and if so what gives to glass used for thermometers this property.

The experiments thus far made are much less numerous and complete than is desirable; and the authors hope they may be able at some future time to make additional experiments with the same and other bars, and also to investigate the properties of glass used for thermometers. Two inferences are suggested, however, by these experiments, viz: 1st, that zinc is not a reliable metal for one of the components of a metallic thermometer, much less for a standard of length; 2d, that bars of steel, copper and brass are not likely to vary in length appreciably at any temperature within the range of temperature to which standards are ordinarily subjected.*

ART. LXIX.—*On Scovillite, a new phosphate of Didymium, Yttrium and other rare earths, from Salisbury, Conn.*; by GEORGE J. BRUSH and SAMUEL L. PENFIELD.

IN October last, Mr. Joseph S. Adam, formerly an assistant in the Sheffield Laboratory, but now chemist of the iron furnaces at Lime Rock, Conn., sent one of us a mineral he had discovered occurring sparingly as an incrustation on some of the iron and manganese ores from the Scoville ore bed in Salisbury, Conn. Mr. Adam found the mineral to be a hydrous phosphate, and sent it to us for further identification.

The specimens which Mr. Adam kindly furnished us for examination show the mineral incrusting limonite and pyrolusite, very much as gibbsite coats the limonite of the Richmond ore bed. The incrustation is one-sixteenth of an inch or less in thickness, and is frequently botryoidal or stalactitic in form. On the cross fracture it presents a radiated fibrous structure. The color is of a pinkish, brownish to yellowish white. It has a silky to vitreous luster on the fracture, but the natural surfaces have a greasy look, and in luster and color, as well as in form of occurrence, the mineral resembles some varieties of chalcedony or smithsonite. Hardness = 3·5. Specific gravity 3·94–4·01.

* The authors desire to acknowledge their indebtedness to Mr. T. Russell and Mr. C. V. Mersereau for the loan of parts of the apparatus owned by them, and to Mr. G. Y. Wisner for assistance rendered in the preparation of the copper and brass bars.

The preliminary examination proved the mineral to be an infusible hydrous phosphate, affording no coloration when treated with cobalt solution, but when fused with salt of phosphorus and borax it gave a remarkable rose-colored bead, both in the oxidizing and reducing flames. The mineral is soluble in hydrochloric and nitric acids. Qualitative analysis showed it to be essentially a hydrous phosphate of the cerium and yttrium metals with a trace of iron and a small amount of carbonic acid. As so few minerals contain these rare earths, and the methods for their separation and determination are frequently attended with difficulty and uncertainty, we have thought proper to give in detail the methods employed in the analyses.

The mineral was dissolved in hydrochloric acid and the metals were precipitated from the acid solution as oxalates. The oxides obtained from igniting this precipitate were easily soluble in dilute acids, giving light rose-colored solutions from which, on addition of a solution of potassium sulphate, a precipitate of the sulphates of the cerium metals was separated. This precipitate, first freed from all traces of the yttrium metals, gave no reaction for cerium when tested by Gibbs's method* with peroxide of lead, but solutions of the oxides examined with the spectroscope showed the absorption bands characteristic of didymium. An acetic solution of the oxides was supersaturated with ammonia, and the precipitate which was formed was filtered off and thoroughly washed; this precipitate, when sprinkled with iodine, gave the characteristic blue coloration due to the presence of lanthanum.†

In the filtrate from the precipitated sulphates of the cerium metals, the yttrium metals were thrown down as oxalates from hot acid solutions. The precipitate had a faint pink color, and when ignited and dissolved in acid the solution showed with the spectroscope the erbium absorption bands. The spark spectrum showed that yttrium was also present.

In the quantitative analyses, owing to the scarcity of pure material, the separate determinations were made on small quantities so as to give chances for repetition or variations in the method if necessary. The analyses were made on the air-dried mineral. It was found that the powdered mineral lost water, but it soon assumed a constant weight when dried at 100° C. The mineral dried at 100° and then ignited in a Bohemian glass tube gave the more firmly combined water which was collected in a chloride of calcium tube and weighed. Carbonic acid was determined by dissolving the mineral in a flask with dilute hydrochloric acid and collecting and weighing the liberated gas in potash bulbs. In analysis II the mineral, after drying at

* W. Gibbs, this Journal, II, xxxvii, 352.

† Fresenius' Qualitative Analysis (Johnson's edition), p. 125.

100°, was directly ignited over the blast lamp, giving a loss of water and carbonic acid agreeing closely with the sum of the separate determinations in analyses I and III. One direct determination of phosphoric acid was made with ammonium molybdate, analysis IV. After filtering off the phosphorus precipitate the bases were precipitated from the filtrate by means of ammonia, and after the separation of traces of molybdenum and the cerium metals a volumetric determination of iron was obtained.

For the separation of phosphoric acid from the bases the following method was adopted. The mineral being easily soluble in hydrochloric acid, a solution containing little free acid was obtained; this was poured into about 500 c.c. of boiling water containing enough ammonium oxalate in solution to unite with the bases to form oxalates; the separation of a crystalline precipitate of the oxalates soon took place, which was quite free from phosphoric acid and contained all but traces of the bases; the solution and precipitate were allowed to stand over night, then filtered and washed with hot water. The filtrate was evaporated to small bulk and the remaining oxide precipitated along with some phosphoric acid from the hot solution by means of ammonia. This small precipitate was collected and weighed and the oxides separated from the phosphoric acid by means of mercurous nitrate.* From the filtrates the phosphoric acid was precipitated with magnesia mixture. The precipitates of the oxalates were brought together, strongly ignited over the blast lamp and weighed. After weighing they were dissolved in sulphuric acid and to the solution enough hot concentrated potassium sulphate solution was added to give when cold a saturated solution and thus cause the precipitation of the lanthanum and didymium. These metals were not separated, but an attempt was made to determine the quantity of the didymium by igniting the nitrates obtained from a weighed quantity of the oxides in a current of oxygen, which should give, according to B. Brauner,† the higher oxide of didymium Di_2O_5 and La_2O_3, and from the gain in weight of the oxide it was hoped that the quantity of didymium could be calculated. The results however were unsatisfactory, the gain in four trials being 7·5, 8·6, 6·9 and 8·2 per cent of the oxide employed. Pure didymium oxide with atomic weight 146·58 would require an increase of 9·38 per cent. A determination of the combined atomic weight of these oxides, made by converting a known weight of oxide into anhydrous sulphate gave 142·6, which was the number used in calculating the results of the analyses.

* Rose, Quantitative Analyse, p. 524.

† Ber. der Deutsch. Chem. Gesellsch., xv, 115.

The filtrate from the precipitated sulphates of the cerium metals was treated with ammonium oxalate to separate the yttrium metals. The precipitate of the latter being impure, it was in all cases redissolved and reprecipitated, and after ignition weighed as oxides. No attempt was made to separate yttrium from the erbium. A determination of the combined atomic weight of the two oxides, made by converting a known weight of oxide into anhydrous sulphate, gave 115, indicating that the proportion of yttrium is about twice that of the erbium. Analyses I, II, III and IV were made on about ·5 gram; analysis V on about a gram. The results are as follows:

	I.	II.	III.	IV.	V.	Mean.	Ratio.	
P_2O_5		24·96	25·03	25·00	24·77	24·94	·1756	
(Y_2O_3,Er_2O_3)		8·34	8·67		8·51	8·51	·0306	
(La_2O_3,Di_2O_3)		55·30	54·87		55·34	55·17	·1656	·1977
Fe_2O_3				·24	·26	·25	·0015	
Combined H_2O	5·88					5·88	·3267	
CO_2+H_2O		9·36						
H_2O lost at 100°		1·50	1·49			1·49	·0828	
CO_2			3·59			3·59	·0814	
						99·83		

In discussing these analyses the question at once arises as to whether the carbonic acid found is an essential constituent of the mineral. The carbonate does not appear to bear any simple relation to the phosphate, and we have thought best to regard it as due to an admixture of lanthanite $(La, Di)_2(CO_3)_3 9H_2O$. Regarding the water given off at 100° C. as representing only three molecules in the above formula, the remaining six going off at a higher temperature, we have the following ratio calculated with CO_2 as a basis:

$$R_2O_3 : 3CO_2 : 9H_2O = {\cdot}0271 : {\cdot}0814 : {\cdot}2456 = 1 : 3 : 9{\cdot}06$$

and there remains, after deducting the above, the ratio

$$R_2O_3 : P_2O_5 : H_2O = {\cdot}1756 ; {\cdot}1706 : {\cdot}1639 = 1 : 0{\cdot}97 : 0{\cdot}93$$

or the ratio of a normal phosphate, plus one molecule of water $= R_2(PO_4)_2H_2O$.

If the water given off at 100° alone belongs to the carbonate, we have the following ratio for the carbonate:

$$R_2O_3 : CO_2 : H_2O = {\cdot}0271 : {\cdot}0814 ; {\cdot}0828 = 1 : 3 : 3{\cdot}06 = R_2(CO_3)_3\, 3H_2O$$

and for the phosphate:

$$R_2O_3 : P_2O_5 : H_2O = {\cdot}1756 : {\cdot}1706 : {\cdot}3267$$
$$= 1 : 0{\cdot}97 : 1{\cdot}86 = R_2(PO_4)_2\, 2H_2O \text{ nearly.}$$

The former seems the more natural supposition and accounts for a carbonate which is known to exist. The mineral as analyzed may then be considered a mixture of lanthanite with the new phosphate in the following proportion:

Lanthanite $R_2(CO_3)_3 9H_2O$.

CO_2	3·59
$(La, Di)_2O_3$	9·03
H_2O	4·42
	17·04%

Scovillite $R_2(PO_4)_2H_2O$

P_2O_5	24·84
$(Y, Er)_2O_3$	8·51
$(La, Di)_2O_3$	46·14
Fe_2O_3	·25
H_2O	2·95
Scovillite	82·79%
Lanthanite	17·04%
	99·83

Below we have given the 82·79 per cent of scovillite calculated up to 100 per cent, and beside it that of a normal phosphate of the formula $R_2(PO_4)_2H_2O$ calculated from the atomic weights obtained from the analyses and with $(Y, Er)_2O_3:(La, Di)_2O_3=1:4$.

	Scovillite found.	Calculated.
P_2O_5	30·12	29·46
$(Y, Er)_2O_3$	10·28	11·51
$(La, Di)_2O_3$	55·73	55·29
Fe_2O_3	·30	----
H_2O	3·57	3·74
	100·00	100·00

The only mineral which approaches this composition is churchite,* a phosphate of cerium, didymium and lime with four molecules of water. Our mineral contains less water, is free from cerium and lime, and differs also entirely from churchite in physical characters. It is, therefore, a new mineral species, and we propose for it the name *Scovillite*, after the locality where it was found. As to the admixture of the carbonate with the phosphate, we have been unable to decide whether this was due to a simultaneous deposit of lathanite with scovillite, or whether the lanthanite is subsequent in formation to the scovillite and a product of its alteration. At all events the carbonate is very intimately and constantly mixed with the phosphate, as we have found no single fragment which would not give off carbonic acid when dissolved in acid. The carbonate, if resulting from the alteration of the scovillite, is not present as a superficial coating because the fragments when dissolved in acids continue to give off carbonic acid until they are completely dissolved. We take pleasure in acknowledging our indebtedness to Mr. Adam for calling our attention to the peculiar character of this mineral, as well as for his kindness in supplying us with the material for examination.

Sheffield Scientific School, May 8, 1883.

* Chemical News (1865), xii, 121 and 183.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *A Numerical Estimate of the Rigidity of the Earth;* by G. H. Darwin, F.R.S. (Proceedings of the British Association for 1882.)—About fifteen years ago Sir William Thomson pointed out that, however it be constituted, the body of the earth must of necessity yield to the tidal forces due to the attraction of the sun and moon, and he discussed the rigidity of the earth on the hypothesis that it is an elastic body.

If the solid earth were to yield as much as a perfect fluid to these forces, the tides in an ocean on its surface would necessarily be evanescent, and if the yielding be of smaller amount, but still sensible, there must be a sensible reduction in the height of the oceanic tides.

Sir William Thomson appealed to the universal existence of oceanic tides of considerable height as a proof that the earth, as a whole, possesses a high degree of rigidity, and maintained that the previously received geological hypothesis of a fluid interior was untenable. At the same time he suggested that careful observation would afford a means of arriving at a numerical estimate of the average modulus of rigidity of the earth's mass as a whole. The semidiurnal and diurnal tides present phenomena of such complexity, that it is quite beyond the power of mathematics to calculate what these heights would be, if the earth's mass were absolutely unyielding. But the tides of long period are nearly free from the dynamical influences which render those of short period so intractable to calculation, and must in fact nearly follow the laws of the "equilibrium theory."

In 1867 it was not, however, even definitely known whether or not the tides of long period were of sensible height at any station. Although there has been a continual advance in the knowledge of tidal phenomena since that time, it is only within the last year that there is a sufficient accumulation of tidal observations, properly reduced by harmonic analysis, to make it possible to carry out Sir William Thomson's suggestion. The great advances in knowledge that have been recently made are principally due to the adoption of systematic tidal observation at a great number of stations by the Indian Government. The results of these observations are now being issued yearly by the Secretary of State for India in the form of tide-tables for the principal Indian ports. I have had the pleasure of carrying out the examination of the tidal records, and a detailed account of the work will appear at § 848 of the new edition of Thomson and Tait's "Natural Philosophy," now in the press.

The tides chosen for discussion were a lunar fortnightly declinational tide, and the lunar monthly elliptic tide. These tides must be free from the meteorological disturbances which make the heights of all the solar tides quite beyond prediction. The

fortnightly and monthly tides consist in an alternate increase and diminution of the ellipticity of the elliptic spheroid of which the sea level (after elimination of the tidal oscillations of short period) forms a part. There are two parallels of latitude, respectively north and south of the equator, which are nodal lines, along which the water neither rises nor falls. When, in the northern hemisphere, the water is highest to the north of the nodal line of evanescent tide, it is lowest to the south of it, and *vice versa;* and the like is true of the southern hemisphere. If the ocean covered the whole earth the nodal lines would be in latitudes 35° 16′ N. and S. (at which latitudes $\frac{1}{3} - \sin^2 lat.$ vanishes); but when the existence of land is taken into consideration, the nodal latitudes are shifted. Now according to Sir William Thomson's amended equilibrium theory of the tides, the shifting of the nodal latitudes depends on a certain definite integral, whose limits are determined by the distribution of land on the earth's surface.

For the purpose of examining the tidal records, it was therefore first necessary to evaluate this integral. Approximation is of course unavoidable, and for that end the irregular contours of the continents were replaced by meridians and parallels of latitude, and the integrals evaluated by quadrature. This procedure will give results quite accurate enough for practical purposes. It appeared as the result of the quadrature that, if we assume the existence of a large antarctic continent, the latitude of evanescent tide is 34° 40′, and if there is no such continent it is 34° 57′. Hence the displacement of the nodal latitudes due to the existence of land is very small.

This point having been settled, the mathematical expressions for the fortnightly and monthly tides are completely determinate, according to the equilibrium theory, with no yielding of the earth's mass.

If there is yielding of the earth, either with perfect or imperfect elasticity, and with frictional resistance to the motion of the water, the height of tide and the time of high-water must depart from the laws assigned by the equilibrium theory. This conclusion may also be stated in another way, which is more convenient for practical purposes; for we may say that at any station there must actually be a tide with a height equal to some fraction of the full equilibrium height and with high-water exactly at the theoretical time, and a second tide, of exactly the same nature, with a height equal to some other fraction of the equilibrium height, but differing in the time of high-water by a quarter-period from the theoretical time, viz: about three-and-a-half days for the fortnightly and a week for the monthly tide. These two tides may, according to geometrical analogy, be called perpendicular component tides. According to the theory of the composition of harmonic motions, the two components may be compounded into a single tide, with time of high-water occurring within a half-period of the theoretical time; and this is the way

in which the results of elastic yielding and frictional resistance were first stated above. Thus the actual tide at any station involves two unknown fractions, x and y, being the factors by which two components, each of the full theoretical height, are to be multiplied in order to give the two components in proper amount to represent the reality.

If the equilibrium theory is fulfilled without sensible elastic yielding of the earth, the first component has its full value, or x is equal to one, and the second component vanishes, or y is zero. If fluid friction exercises a sensible influence, y will have a sensible value; and if the solid earth yields tidally, x will be less than unity. The amount of elastic yielding, and hence the average modulus of elasticity of the whole earth may be computed from the value of x. After rejecting the observations made at certain stations for sufficient reasons, I obtained from the Tidal Reports of the British Association and from the Indian Tide Tables, the results of thirty-three years of observation, made at fourteen different ports in England, France and India.

These results, when properly reduced, gave thirty-three equations for the x and thirty-three for the y of the fortnightly tide, and similarly thirty-three for the x and thirty-three for the y of the monthly tide; in all 132 equations for four unknowns.

The x and y of the two classes of tide were in the first instance regarded as distinct, but the manner in which they arise shows that it is legitimate to regard them as identical, and thus we have sixty-six equations for x and sixty-six for y.

The equations were then reduced by the method of least squares, with the following results:—

For the fortnightly tide—

$$x = \cdot 675 \pm \cdot 056, y = \cdot 020 \pm \cdot 055$$

And for the monthly tide—

$$x = \cdot 680 \pm \cdot 258, y = \cdot 090 \pm \cdot 218$$

The numbers given with alternative signs are the probable errors.

The very close agreement between the x and y for the two tides is probably somewhat due to chance.

The smallness of the two y's is satisfactory; for, as above stated, if the equilibrium theory were true, they should vanish. Moreover, the signs are in agreement with what they should be, if friction is a sensible cause of tidal retardation. But considering the magnitude of the probable errors, it is of course more likely that the non-evanescence of the y's is due to errors of observation or to the method of reduction.

I have already submitted to the British Association at this meeting a paper on a misprint, discovered by Professor Adams, in the tidal report for 1872. This report forms the basis of the method of harmonic analysis which has been employed in the reduction of the tidal observations, and it appears that the erroneous formula has been systematically used. The large probable

error in the value of the monthly tide may most probably be reduced by a correct treatment of the original tidal records.

It has been already remarked that it is legitimate to combine all the observations together, for both sorts of tide, and thus to obtain a single x and y from sixty-six years of observation. Carrying out this idea I find:

$$x = \cdot676 \pm \cdot076, \quad y = \cdot029 \pm \cdot065$$

These results really seem to present evidence of a tidal yielding of the earth's mass, and the value of the x is such as to show that the effective rigidity of the whole earth is about equal to that of steel.

But this result is open to some doubt for the following reason: Taking only the Indian results (forty-eight years in all), which are much more consistent than the English ones, I find

$$x = \cdot931 \pm \cdot056, \quad y = \cdot155 \pm \cdot068$$

We thus see that the more consistent observations seem to bring out the tides more nearly to their theoretical equilibrium values with no elastic yielding of the solid.

It is to be observed, however, that the Indian results being confined within a narrow range of latitude give (especially when we consider the absence of minute accuracy in my evaluation of the definite integral) a less searching test for the elastic yielding than a combination of results from all latitudes.

On the whole we may fairly conclude that, while there is some evidence of a tidal yielding of the earth's mass, that yielding is certainly small, and that the effective rigidity is at least as great as that of steel.

2. *On Ripple-marks.*—Two memoirs on the formation of ripple-marks have recently appeared; one, by Mr. A. R. Hunt, in the Transactions of the Royal Society for 1882, and the other by Mr. C. DeCandolle, in the Geneva Archives des Sciences for March 15, 1883. The latter is the more thorough in its treatment of the subject, and gives experimental illustrations. The author announces early in his paper the following general law as the result of his study.

When any viscous matter in contact with a liquid of less viscosity undergoes oscillatory or intermittent friction resulting from movement in the overlying layer, or from its own displacement relatively to this layer, (1) the surface of the viscous matter becomes rippled perpendicularly to the direction of the oscillation, and (2) the distance between the ripples so formed is in direct ratio to the amplitude of the oscillation.

The expression *viscous matter* here includes not only liquids that are evidently viscous, as syrups, tar, etc., but also mixtures of insoluble powders with non-viscous liquids, mixtures which are never as perfectly fluid as these liquids themselves. Even collections of bubbles of air on the surface of water produce in the mass a feeble degree of viscosity, sufficient to give origin to ripples, as the author has proved by his experiments. If the

two liquids of unlike degree of viscosity are not at all miscible, like mercury and water, or oil of turpentine and water, ripples are not made; but if powdered quartz or barite covers the mercury a mixture of some viscosity is produced by the friction and ripples will form.

Ripples are then the result of oscillatory or intermittent friction. A wave, whether stationary or propagating itself, involves, at the same instant, (1) a change of surface level, and (2) a horizontal oscillation of the liquid molecules; whence the surface against which the wave acts experiences simultaneously a normal impact and oscillatory friction; and this friction is especially pronounced when the motion of the liquid consists in a simple uninodal undulation. No general movement of the mass is necessary.

Thus, the problem of the formation of rippled surfaces is that of the formation of friction waves. In the memoir, the statement of the author's general conclusion is followed by an account of his various experiments, in illustration of which there are four photographic plates representing the rippled surfaces obtained. The first experiments were made in open glass troughs of water to which an undulating motion could be given by moving the trough, or the water directly; the ripples were "*ripples of undulation.*" Each ripple terminated above in a crest consisting of the lighter particles if these were of unequal sizes; and the distance between the ripples was always the same if the amplitude of oscillation and depth were the same. Other experiments were made to ascertain the effects of a rotatory movement in the liquid. The ripples thus produced the author calls *ripples of rotation.* They are radiating ripples, and their distance apart depends, as before, on the amplitude of the oscillatory friction.

With regard to *ripple-marks made in connection with the flow of waters,* like those over sand-flats, the author's experimental trials were not successful. The author says that they are *the result of friction rendered intermittent by continual variations in the velocity of the flow.* He explains in the same way the ripple-marks made over surfaces of dry sand by the winds. The above statement as to their origin does not appear to be quite adequate; for the needed undulations, or intermittent action in flowing waters is chiefly a *consequence of the friction* over the mobile sands, while in the first case the undulation is of independent source. The movement makes the "viscous" mixture as before, but the resistance intermittently overcome produces the undulation in the water and the intermittent deposition. The wave-movement in waters not sensibly flowing produces *ripples of undulation;* and these should graduate imperceptibly into *ripples of translation* as the waters change to shallower flowing waters. Both kinds, however, come under the general law deduced by the author, above cited. As to the depth at which ripples may form, the author quotes an article by the brothers E. F. and W. Weber, published at Leipzig in 1825, in which it is stated, as

the result of experiment, that the oscillation of waves may be appreciable at a depth equal to 350 times the height of the waves.

Mr. DeCandolle suggests that the ripple-like arrangement of clouds may come into the same category with the wind-ripples over dry sands, and that if so, the parallel lines of clouds should be at right angles to the direction of the wind. J. D. D.

3. *Direct vision Spectroscope of great dispersion.*—The dispersion of direct vision spectroscopes does not in general exceed 20° from the A line to the H line. M. Ch. V. Zenger joins to a parallelopipedon of dispersion a prism of light crown glass and obtains a dispersion of 150°, which he claims is only exceeded by the spectroscope of M. Thollon, in which the number of prisms of bisulphide of carbon and multiple reflexions diminish the intensity of the light to a great degree. The combination of M. Zenger is subject in a less degree than M. Thollon's to these reflexions and the loss by absorption is claimed to be small. As an example of the proposed arrangement M. Zenger gives the calculation for a combination of three prisms. One of the prisms was made of quartz (extraordinary refraction), another—a liquid prism—was filled with a mixture of 4 parts of ether to 6 parts of benzine. These two prisms were combined so as to form a parallelopipedon. The limiting angle of the liquid prism for the line A was found to be 76° 11′. A crown glass prism was then placed so as to refract the beam of light which passed through the parallelopipedon. The refracting angle of this crown glass prism was made 27° 13′. With this arrangement a total dispersion of 132° 55′ was obtained. The total dispersion was equivalent to that of thirteen or fourteen bisulphide of carbon prisms of 60°.—*Comptes Rendus*, April 9, 1883, pp. 1039–1041. J. T.

4. *The transmission of power by electricity.*—An interesting report upon this subject has lately been presented to the French Academy by M. Cornu in behalf of a commission which was appointed to examine the experiments of M. Depretz. A careful analysis of the results of the various experiments is given with the following summary:

The work absorbed by the generatrix and transmitted to the receptrix, increases with the velocity of the generatrix. M. Depretz has succeeded in transmitting nearly four and one-half horse power through a resistance of 160 ohms which represents a double telegraph line of $8{\cdot}5^{km}$. The work received was 37½ per cent of that spent.

With a greater velocity of the generatrix it seems possible to transmit power to greater distances than M. Depretz has attained. This amounts to saying that a high electromotive force is necessary for this end.—*Comptes Rendus*, April 9, 1883, pp. 992–1010.

J. T.

5. *The radiation of rock-salt at different temperatures.*—C. BAUR by means of a bolometer has studied this question, which the researches of Melloni and Magnus have left undecided. The conclusions reached are as follows:—

Rocksalt absorbs its own rays more strongly than those of other bodies.

The absorption increases as the difference in temperature between the radiating and absorbing rocksalt plates diminishes.

The absorption reaches its full value when the difference in temperature between two such plates is nothing. Baur does not believe with Magnus that the radiations from rocksalt are homogeneous; but concludes that long waves are accompanied more or less with longer and shorter waves, just as a yellow glowing solid body sends forth not only yellow but also radiations of a greater wave length.—*Annalen der Physik und Chemie*, No. 5, 1883, pp. 17–21.
J. T.

6. *Application of Organic acids to the Examination of Minerals*, No. 3; by H. Carrington Bolton, Ph.D.—Professor Bolton has continued his investigations as to the action of organic acids on minerals, and obtained some additional results of interest. The acid employed was citric acid, which, as the author has shown, has a power of decomposing minerals little less than that of hydrochloric acid; the effect of prolonged action at ordinary temperatures was especially considered. Of the sulphides, chalcocite showed signs of decomposition at the end of ten days, and after several months a partial solution of a green color was obtained; pyrite was slightly attacked in eight days, and a month later a solution of a reddish-yellow color was obtained; chalcopyrite acted similarly, one gram lost 11 per cent after fourteen months' contact with the acid solution. Of the oxides, magnetite and limonite were experimented upon and found to be strongly attacked in eight days, hematite yielded more slowly, showing decided decomposition after several months. Of the silicates, datolite was most quickly decomposed, yielding gelatinous silica after twenty-four hours; hornblende, pyroxene, almandite, epidote, vesuvianite and serpentine were decidedly decomposed in eight days, and after fourteen months the first two were completely decomposed, the serpentine after the same time yielded a dry gelatinous mass. The feldspars were unequally attacked under like conditions, labradorite yielded most easily, orthoclase and oligoclase showed marked signs of decomposition after eight months, while albite is still doubtful. Tourmaline and staurolite yielded after four or five months, while talc and cyanite seemed to resist attacks. Muscovite and biotite yielded very slowly, the latter showing signs of decomposition the sooner. The author gives a table which shows the approximate relative disintegration of rock-forming (and associated) minerals by citric acid in solution. Those *quickly decomposed* are the carbonates, phosphates, prochlorite, chrysolite and nephelite; those *slowly decomposed* are serpentine, pyroxene, hornblende, labradorite, garnet, epidote, vesuvianite, pyrite, limonite, magnetite, gypsum (?); those *very slowly decomposed* are orthoclase, oligoclase, albite (?), biotite, muscovite, tourmaline, staurolite, hematite; *not decomposed* are quartz, corundum, spinel, beryl, fluorite, barite, talc (?), cyanite (?). The author suggests

that the above facts may have an important bearing upon some evident geological phenomena, but does not discuss the matter further. A series of concluding tables shows in detail the behavior of a large number of minerals with citric acid alone and with reagents.

II. Geology and Mineralogy.

1. *On Pot-holes on the edge of a bluff at Gurleyville, Connecticut;* by Professor B. F. Koons. (Communicated.)—Last November I discovered an interesting group of pot-holes upon the edge of a bluff at Gurleyville, Conn., on the east side of the Fenton River, four miles above its mouth.

Recently, in company with Professor Washburn, I have cleared the one perfect one of its water and stones, and found it to be six feet seven inches in depth, three feet nine inches in its shorter diameter at the top, and four feet three inches in its longer diameter.

About two feet above the bottom the diameter is reduced to about thirty inches, and then widens again below this point, leaving a horizontal ring at the narrow place. What can have been the cause of the forming of the ring at this point is not entirely evident. If the rock were horizontal it would seem that a hard layer in the rather uniform gneiss would account for it; but since the rock dips at an angle of about 30°, and this projecting ring is horizontal and only a couple of inches thick, I find myself at a loss for an entirely satisfactory answer.

This pot-hole is near the edge of the cliff and the remnants of three others appear upon the face of it; and one of these three shows a diameter of nine feet and a depth of six. All are within a few feet of each other, a couple of them separated by a thin partition only. They are upon the projecting point of a cliff at the foot of a narrow passage through which the glacial stream made its way, and just where an eddy would be formed by the rushing waters as they spread out into the wider plain below. The group is all the more interesting from the fact that the pot-hole highest on the cliff stands ninety-eight feet six inches above modern flood plain, while the highest terraces to be found in the vicinity are only fifty-six feet six inches high.

Storrs Agricultural School, Mansfield, Conn., April 21st, 1883.

2. *The Geology of Pike and Monroe Counties, Pennsylvania,* by I. C. White; *and Special Surveys of the Delaware and Lehigh Water Gaps,* by H. M. Chance.—The publication of this volume of the Geological Survey of Pennsylvania is announced on page 310 of this volume. Pike and Monroe Counties are on the eastern border of the State, with only the county of Wayne between Pike and the northern boundary. Mr. White's volume treats of many points of great interest, with a full supply of facts from his careful observations.

The front or eastern edge of the great plateau of the two

counties—1200 to 2000 feet above the sea-level—is made by an irregularly continuous mountain wall, a thousand feet high and precipitous, broken only by short ravines, the southern part of which is called Pocono Mountain. The rocks of the plateau are nearly horizontal, as in the corresponding plateau of the Catskill Mountain region to the northeast. A map accompanying the Report, by Professor Lesley, represents the Catskill Mountain escarpment as continued, though with diminished height, in the escarpment through Pike County, and then with increase of elevation again, through Monroe County along Pocono Plateau and Mountain, about 2000 feet in elevation, from which the surface southward falls off precipitously 1200 to 1300 feet. Pike County, over its higher parts, is covered with rocks of the Catskill group. The Kittatinny Mountain, consisting of Devonian and Silurian strata, down to the Hudson River slates, extends along the eastern border of the counties on the New Jersey boundary.

The *glacial scratches* over the counties have in general a course of S. 30° W., except where locally diverted. This course is that also over the Kittatinny or Blue Mountain. The abrading action of the glaciers over the region was small, and "exerted practically no influence in modifying the general topography;" but much tearing or disrupting was done over the jointed rocks.

The district is "remarkable for the number and variety of its *buried valleys*." "Between Port Jervis and the Water Gap, the Delaware River flows over an old river channel silted up to a depth of perhaps 100 feet." Other buried valleys are the Stroudsburg and Flat Brook. In the case of the southern branch of the Stroudsburg, "the rapid narrowing up and disappearance of this *buried valley* is coincident with the disappearance of the Terminal Moraine which spreads over the valley of Upper Frantz's Creek. There is therefore little doubt that *subglacial rivers* did both widen and deepen it to a considerable extent, for Frantz's Creek, after entering the *driftless* region, flows along its narrow valley in the same soft Marcellus shale which underlies its wide drift-filled eastern prolongation." The author observes that the facts show that the direct abrading action of the glacier over the soft rocks must have aided in the excavation. Among buried valleys there are "also post-glacial rock-cuts" as in the new channel of Wallenpaupack Creek, of Blooming Grove Creek, Shohola Creek, Sawkill River, and others.

The larger part of Mr. White's Report is occupied with the stratigraphy of the counties and of part of the adjoining Carbon County to Mauch Chunk. In the course of the descriptions it is stated that while the thickness of the Catskill series was found by the author, as before reported, to be 1530 feet on the northern boundary of Wayne County; in Pike County, near Wayne, it is 3430 feet; along the Lehigh, below Mauch Chunk, 7544 feet.

The unconformability of the Oneida Conglomerate or lowest member of the Upper Silurian over the Hudson River shale or top of the Lower Silurian, is spoken of "as finely shown at a cut

on the Erie railroad, a mile west from Otisville, in New York," the dip of the former being 28°, and of the latter 43°, the direction in each case north-northwest; and, besides, the latter rock has an eroded surface and chips of it occur in the conglomerate. Similar evidences of unconformability were observed at the Lehigh Water Gap.

From the prefatory letter, introductory to the Report, by Professor Lesley, Director of the Geological Survey, we cite the following:

"The body of the Catskill plateau consists of the Catskill formation (uppermost Devonian, No. IX of the former survey), about 5000 feet thick, and the peaks are what remains of the overlying gray Subcarboniferous, the Pocono formation (No. X), which formerly spread continuously over the Catskill beds. Mr. White has illustrated this point by facts from Wayne, Pike and Monroe Counties. Above the latter the Mauch Chunk Red shale formation (No. XI), the Pottsville Conglomerate (No. XII), and the Coal Measures (No. XIII), once lay; whence Mr. Lesley concludes the original height of the Catskill Mountain mass must have been at least 11,000 feet, if not 12,000 feet.

The Catskill table-land is at least 125 miles long, half in New York, half in Pennsylvania. From Pocono Mountain it extends westward into Carbon County as the Nesquehoning Mountain, and northward as Moosic Mountain, and again westward, by the Elk Mountains, across the Susquehannah River, becoming the North or Allegheny Mountain uplands. He observes that it must be regarded as one broad synclinal rising toward the northeast, through which run lengthwise (N.E. and S.W.) gentle anticlinal undulations, that west of the Delaware become steep anticlines.

The fact of the increase in thickness and coarseness of the Paleozoic fragmental beds from New York to Alabama points to, if it does not prove, says Professor Lesley, "the derivation of the sediments from the Archæan highlands of New England, Southern New York, Northern New Jersey, the South Mountains of Pennsylvania, the Blue Ridge range of Virginia and the Black Mountains of North Carolina; or, in place of some of these, which were early covered with Paleozoic sediments, to Archæan Alps still farther off, now buried beneath the shore deposits or beneath the waters of the Atlantic."

Professor Lesley mentions the course of the "terminal moraine" as ascertained by Mr. Lewis, who has this subject in charge, but adds that the existence of ice-striæ on the crest of Locust Mountain, west of Ashland and 25 miles south-southwest of the nearest part of the great moraine, suffices to show that much is yet uncomprehended.

The Report contains a large colored geological map, by Mr. White, and sections and maps by Mr. Chance.

3. *Geology of Philadelphia County and of the other parts of Montgomery and Bucks Counties*, by Charles E. Hall, with

analyses of rocks by Dr. F. A. Genth and F. A. Genth, Jr. 144 pp. 8vo, with maps.—Mr. Hall's volume is one of the most important that has come from the Second Geological Survey of Pennsylvania. The author describes and represents in sections the conformability of the crystalline limestones, hydromica schist and other crystalline schists, and quartzytes, proving that all are of one series and none of them older than Lower Silurian. The facts prove that the rocks are a continuation of the Taconic and other formations of the Green Mountain region, being similar both in lithological characters and stratigraphical relations.

4. *On the Relations of the Triassic traps and sandstones of the Eastern United States;* by WM. M. DAVIS. Bulletin of the Mus. Comp. Zool., vol. vii (Geol. series, vol. i), 8vo, pp. 249–309, with numerous sections.—This paper is the full memoir on the Triassic sandstones and trap of Eastern North America which the author promised in his abstract of his views given in the last volume of this Journal (p. 345).

The uniformity in features of the long trap ridges in the Triassic areas of Eastern North America, the trap in all those of a nearly north and south course having a bold columnar front in one direction and a gradual slope in the opposite, and their occurrence in long lines, sometimes in many nearly parallel, as well shown on Percival's map, have led most observers, as they did Percival, to regard all as intrusive, but with lateral outflow to some distance between layers of sandstone. The object of Professor Davis's memoir is to show, as the result of his investigations, that, notwithstanding this uniformity, part of the trap ridges are intrusive, and part *overflows* covered by beds of the sandstone of later origin, which tilting and faulting have put into their present positions. He makes the Palisades, on the Hudson, East Rock and West Rock ridges, near New Haven, and some others, to be certainly intrusive, but many others, undistinguishable from these in general features, to be overflows. The occurrence of any amygdaloid in the trap is regarded by him, for reasons which he gives, as one evidence of an overflow.

The author's sections make his views clear to the reader. In his text he is strong in many of his statements as to the conclusions from his investigations, but says that in Connecticut much observation is still necessary to decide finally on the origin of the numerous ridges. The writer has made many observations in Connecticut bearing on the question at issue, and has not yet detected any satisfactory evidence of the overflows. A discussion of the subject is deferred until further observations can be made, when the facts, for or against, will be presented.

As to the origin of the vesicular texture of the amygdaloid the writer has always held, in agreement with the author, that the feature was due to "a decrease of pressure which allowed the occluded gases and vapors to separate from the surface of the overflowing mass;" that is, if this means a decrease of pressure which allowed the moisture or other material in the melted rock

to become vapor toward its surface or in its outer portion. But the indications of moisture in the trap of the ridges are not in the amygdaloidal cavities alone, or chiefly, but vastly more in the general hydration of the trap, rendering it chloritic at the expense of the pyroxene or pyroxene and feldspar. Often a very small part only, if any, of a hydrous trap ridge is amygdaloidal; the hydrous condition appears to belong to the mass. And this is parallel with common facts in other regions, such hydrous trap (sometimes called melaphyre), being frequently the only kind. The feature is independent of pressure, and is a prerequisite to the amygdaloidal. The distinction to which the observations of E. S. Dana seemed to lead was that the masses of the several trap ridges in Southern Connecticut became gradually more and more chloritic, or hydrous, on going from west to east over the Triassic area; and that the amygdaloidal feature was a subordinate one, occasionally observed where the hydration was greatest. J. D. D.

5. *Glacial phenomena of Long Island*, by JOHN BRYSEN, Esq. (Geological Magazine, April, 1883, x, p. 169.)—This paper, on Long Island Glacial phenomena, is by one who says of himself that he is "by no means a scientist." We believe this statement, and see little else in the paper to accept with so much confidence. The author informs his readers much that nobody else knows. He says that in the Glacial era "the Sound [Long Island Sound] or [and] East River did not yet exist"; the "waters flowed *around* not through Hurlgate"; "the waters of the Hudson, Connecticut, and other rivers flowed directly into the sea"; the waters of the streams "underneath the glacier," "wild and turbid streams," dammed up by the terminal moraine, broke through the main ridge or back bone of the island; and their depth was so great that the water-worn stones were carried by the current—"not by the drift" to the top of Harbor Hill, the highest point of the island. [The greatest height according to the Coast Survey is 383 feet.] This incredible fact is thought not to seem impossible "when we remember that the glacier was from ten to fifteen thousand feet in thickness," and that "it was *under* the glacier that these mighty torrents prevailed."

6. *Relations of the "Felsyte" to the Conglomerate on Central Avenue, Milton, Mass.*, to the south of Boston.—Professor M. E. WADSWORTH has given the results of his observations on the Milton "felsyte" in the Harvard University Bulletin of October, 1882. They differ widely from those of Professor W. O. Crosby in vol. xix of this Journal (1880). He states that the felsyte is only a somewhat altered portion of the associated conglomerate. It contains in some parts many argillaceous pebbles only partly obliterated, and the two rocks graduate into one another. The conclusion was sustained also by microscopic examinations. Proof of distinct bedding east and west in strike was found to be indicated by lines of finer and coarser sedimentation. A few rods south of the "felsyte" locality, a coarse conglomerate alternates

repeatedly with bands of sandstone, in which occur pebbles of argillyte which vary from a minute size up to a length of one to two feet. The argillyte resembles that "exposed to view on the O. C. Mattapan branch railroad, a short distance to the northwest;" whence the inference that the conglomerate is younger than the argillyte; and Mr. Wadsworth also observes that the conglomerate is of different age from the Roxbury conglomerate of the same part of the Boston basin.

7. *Jointed structure in rocks.*—In a paper on the origin of jointed structures, in the Proceedings of the Boston Society of Natural History for October, 1882, p. 72, Professor W. O. Crosby explains the joints ordinarily so-called, having great uniformity in direction, to the vibrations of earthquakes, stating that the character of the vibrations is such as necessarily to produce fractures, and that all formations have been subjected to severe shocks of indefinite number.

8. *Note on Jointed structure.*—It would appear from Mr. W. J. McGee's note (this Journal, February, 1883, p. 153), that his observations on jointing are strongly in favor of their being due to the contraction of rock masses. As has been mentioned in "Valleys and their relations to Faults, etc." (Trübner & Co., London), chaps. i and ii, very similar phenomena have been observed in Irish limestone and other rocks. Master-joints of different ages, the *clay seams* and *dry seams* of McGee, or the *red end and end* of the Irish quarrymen, usually have different bearings, the younger crossing the older at any angle up to right angles. The older necessarily have opened toward the surface more than the younger, and the shrinkage spaces have become filled with clay; but in depth they have not opened, being still mere lines, that is, a clay seam passing into a dry seam. In the face of the "head" or "clearing" over the marble beds at Galway, Ireland, which in 1865 was over 150 feet high, this was well illustrated. When these quarries ceased working, about 1850, there were no joints in the beds forming the floor of the quarry except "concealed joints," that showed and opened as the blocks were wedged up, but after the floor had laid exposed to the weather about fifteen years, shrinkage had changed all these concealed joints into open joints. G. H. KINAHAN.

9. *Origin of the Crystalline Iron Ores.*—Dr. A. A. Julien read a paper on this subject before the New York Academy of Sciences, in October last (Trans. N. Y. Acad. Sci., ii, p. 6). The author presented the view that the large iron ore deposits of the Archæan were originally made mechanically, like the accumulations of iron-sand along sea beaches; or, in some cases, as he stated at the following meeting, "accumulations upon a sea-bottom strewn alternately with fine siliceous silt and with octahedra of magnetite." Dr. Newberry discussed the subject in reply, admitting that some beds may have been made by "the sorting power of shore waves," but urging that such cases are exceptional, and arguing in favor of the more common theory that they

are derived from the precipitation of iron oxide from its soluble salts in waters receiving the drainage of a region, the waters being, in his view, those of a confined area or lake. Some of the facts regarded by Dr. Newberry as unfavorable to the idea of a mechanical origin, are the thickness of many of the Archæan ore-deposits; their being enclosed sometimes by strata of limestone or of slate, rocks made by *quiet* methods of deposition, unlike those of iron-sand; the occurrence of alternating beds of jasper, another rock of fine and quiet sedimentation; and the existence of beds of aluminous magnetites, which contain almost no silica. Dr. Julien states rightly that some magnetite is associated with much garnet. When this is the case the probability is in favor of the mode of origin he presents—a method hitherto too much overlooked. But Dr. Newberry's position appears to be the right one—that this method is not the usual one, and makes only thin seams of ore.

The beach deposits of iron-sand are made by the fling or forcible transporting action of waves, followed by the action of the returning waters in drifting away from the heavier sands the most of the lighter grains as those of quartz. It is thus that the magnetite and garnet are concentrated on the highest parts of the sand-made beaches, as implied by Dr. Newberry; and hence ore-deposits of this mode of origin are necessarily of small extent, and vary at short intervals in the proportion of siliceous sands. The conditions are such as would not make *sea-bottom* deposits of the ore; and it is questionable whether in deposits so formed the iron-sands are not always distributed throughout the sediments, as is so commonly the case in sandstones.

The successive phases of a coal era—where open seas have alternated with immense salt-water mud-flats or marshes, becoming afterward fresh-water mud-flats, and the reverse, with the transitions between these different states, include the conditions as to confined areas fitted for chemical iron-ore deposits. Such are the conditions which the writer has had in view when speaking of the ore as originally a marsh-made deposit; and such he understands to be the view of Dr. Newberry. J. D. D.

10. *Overturn folds in the Glaronnaise Alps.*—The idea of a double overturn fold in the Glaronnaise Alps, first presented by Escher, and afterward adopted and illustrated with full details by Heim, led to an excursion over the region in 1882 by a party of sixteen geologists, under the guidance of M. Heim, in order to see and understand the facts in the case. The party included Messieurs Lory, de Grenoble, Rothpletz of Munich and Vilanova of Madrid. The result was the general acceptance of Heim's conclusion as to the enormous overturn. M. Lory was fully convinced as to the double fold. M. Rothpletz admitted the existence of the southern fold, but objected to that of the northern, explaining the position of the formations in the latter region by a fault combined with a sliding of the beds.—*M. E. Favre, Archives des Sc. Phys. et Nat.*, III, ix, 180, Feb., 1883.

11. *The Dimetian, Arvonian and Pebidian formations.*—These subdivisions of the Pre-Cambrian, proopsed by Dr. Hicks from his observations at St. David's, on the ground of mutual unconformability, the Pebidian being the youngest, are the subject of a paper by Professor Archibald Geikie, read before the Geological Society in March. Professor Geikie, after an examination of the region, concludes that the *Pebidian* group, which comprises a series of volcanic tufas, breccias and lavas, is an integral part of the Cambrian; the *Dimetian* is eruptive granite intersecting the Cambrian; and the *Arvonian*, eruptive quartz-porphyries or elvans associated with the granite—proof of which was found in natural sections showing the actual intrusion of the elvans across the bedding of the rocks.

12. *On the results of Recent explorations of erect trees containing Animal remains in the Coal Formation of Nova Scotia;* by J. W. DAWSON.—Part II of Dr. Dawson's memoir is published in the Philosophical Transactions for 1882.

13. *Lethæa Geologica; 1 Theil. Lethæa Palæozoica*, von FERD. ROEMER. Textband, zweite Lieferung. 327 – 544 pp., with 65 wood-cuts. 8vo. Stuttgart, 1883. (E. Schweizerbart.)—This part of the Lethæa, by Roemer, is devoted wholly to fossil Corals, and will be found of great service to American paleontologists.

14. *Hemidioryte;* J. D. DANA.—In the writer's paper "on some points in Lithology," published in 1878 in volume xvi of this Journal, I present, on page 434, objections to calling a rock made of mica and a triclinic feldspar a mica-dioryte: stating (1) that the name "diorite" was given originally to a hornblendic rock and (2) that black mica (biotite) and hornblende, although both are ferriferous, are in fact widely diverse minerals, mica, unlike hornblende, being essentially a potash-bearing species, and nearly as much so as orthoclase; and adding that it is, therefore, undesirable, both geologically and lithologically, to put rocks having mica as a characteristic ingredient under the same general name with those that are essentially hornblendic. Accordingly, in my articles on the Cortland rocks in this Journal for 1880 on page 198 of volume xx, I called a rock of the kind here referred to simply a *soda-granite*, in allusion to its resembling granite in aspect and in being a compound of feldspar and mica, with more or less quartz, and to its containing a soda-lime feldspar, oligoclase, instead of orthoclase.

As it is best that the rock should have a distinctive name I would propose for it that of *Hemidioryte*, which recognizes its relation to dioryte, without merging it in the dioryte group.

15. *Jeremeieffite, a new mineral.*—M. DAMOUR has recently described a new borate of alumina from Siberia under the name Jeremeieffite, after the Russian mining engineer Mr. Jeremejew. It crystallizes in regular hexagonal prisms, and thus resembles apatite and beryl in habit. Hardness 6·5, specific gravity 3·28. Transparent and almost colorless with vitreous fracture. An analysis yielded:

B_2O_3 by difference.	Al_2O_3	Fe_2O_3	K_2O
[40·19]	55·03	4·08	0·70 = 100

These results correspond closely with the formula $(Al_2O_3,Fe_2O_3)B_2O_3$. Before the blowpipe it loses its transparency and colors the flame green (boron) without fusing, moistened with cobalt solution it yields a fine blue. It is not attacked by acids except when first ignited at a red heat, when heated sulphuric acid dissolves it. The locality from which this interesting mineral was obtained by the engineer whose name it bears is the Soktoui, southeast of Adun-Tschilon in western Siberia.—*Bull. Soc. Min.*, vi, 20, 1883.

16. *Picro-epidote, a new magnesian epidote.*—MM. DAMOUR and DESCLOIZEAUX have described a new member of the epidote group in which magnesia enters in the place of lime. The crystals which have been examined by M. DesCloizeaux, though too imperfect to allow of exact determination, correspond with ordinary epidote in angle and in optical properties. The crystals are small, transparent to translucent, and of a white or slightly yellowish tint. They scratch glass and are infusible in the blowpipe flame. M. Damour has shown as the result of some qualitative tests that the mineral is a silicate of alumina and magnesia with traces of lime, and it is inferred that the composition must be analogous to that of epidote. The specimens examined were associated with lapis lazuli, calcite, dolomite, diopside and pyrite. The locality is Lake Baikal.

17. *A Text-Book of Mineralogy, with an extended treatise on Crystallography and Physical Mineralogy;* by EDWARD SALISBURY DANA. Revised edition. 521 pp. 8vo. New York, 1883. (J. Wiley & Son.)—The new edition of the Text-Book of Mineralogy contains about fifty pages of new matter arranged in four supplementary chapters. These chapters give descriptions of new instruments for the measurement of crystals, and for the study of their optical properties, illustrated by numerous woodcuts; also an account of new methods of determining the specific gravity of minerals, their indices of refraction, and other related points; further, brief descriptions of new minerals, and a statement of important new facts in regard to the characters and occurrence of old species. The larger portion of the book remains as it was in the earlier edition except as regards occasional corrections, references, and so on. The book has been re-paged, and a new and complete index concludes the volume.

III. BOTANY AND ZOOLOGY.

1. *Jahrbuch des K. Botanischen Gartens und des Botanischen Museums zu Berlin.* Band II, 1883.—The second volume of this new work has promptly come to hand. Dr. EICHLER, the Director of Gardens, and Dr. GARCKE, Curator of the Museum, are associated in the editorship: the latter was the editor of the Linnæa, which the present publication supersedes. The leading article

of the volume is a full Monograph of the *Turneraceæ* by Urban. He retains Aublet's *Piriqueta*, and reduces Dr. Chapman's three species to one, *P. Caroliniana*. The medicinally famous *Turnera aphrodisiaca* is made a variety of *T. diffusa* Willd., which has a wide range and a copious synonymy. The same author has a paper on the biology and morphology of *Rutaceæ*. Wenzig contributes a synopsis of the genera and species of *Pomaceæ*, a summary of his revision in the 38th volume of the Linnæa. A leading physiological article is that of Volkens, on the excretion of water in a liquid form by the leaves of the higher plants. In another, Potonie treats of the arrangement of the conductive bundles in the Vascular Cryptogamia. Dr. Paul Schultz has a very interesting paper on the medullary rays and their relations to the conducting elements in wood. He shows that the medullary rays of Coniferæ are connected with wood-cells by means of pores. These pores in the ray-cells are always unbordered, but in the wood-cells may have the characteristic border of the discoid markings. In a few species of Pinus, with large pores to the ray-cells, the neighboring wood-cells are strengthened at the point of contact by means of delicate cross-beams or braces. True wood-cells were met with in the medullary rays only of the *Abietenæ*, and under two modifications; in the first, the cells are irregularly thickened, in the other they are very narrow and not irregularly lignified. The ray-cells with pores serve as receptacles for water. In Dicotyledons, the ray-cells are united to the vessels by means of pores which sometimes attain a surprising size. Finally, Schulz concludes that woody parenchyma and ray-cells stand in intimate relations to vessels, and that they together form the channels for transfer of organic solutions. This conclusion is based upon experiments made on branches of Horse-Chestnut, in spring. As it is impossible to follow the course of a solution of sugar after it has been made to enter the plant, he used a dilute solution of tannin which was introduced by absorption from a tube in a small aperture going down to the wood. The tannin was afterwards tested for by iron solution. G. L. G.

Dr. SCHRÖTER contributes a short article on the *morphology of the andrœcium of Malvaceæ*, from a study of *Sida* and *Hibiscus*. He confirms the conclusion that the andrœcium arises from five epipetalous stamineal leaves, developed earlier than the petals themselves, and multiplying both by collateral and transverse chorisis; but he finds no evidence in *Hibiscus* of an inner and episepalous series of stamens. The decisive plant to study in this regard is *Sidalcea diploschypha*. And we beg seeds of this from our Californian correspondents, that we may place them in the hands of the proper investigators. A. G.

2. *Flora of the Southern United States.*—The crying want has at length been supplied. Dr. Chapman has brought out a second edition of his Flora of the Southern States east of the Mississippi. The preface to the new issue has the date of December 26, 1882. The Supplement was printed and some copies distributed at the

close of winter. But the volume, a reissue of the original edition, with some typographical corrections, with appended supplement, comes to hand only in May, rather late for this year's use in the southern Colleges, and by the botanical amateurs who winter in Florida. The supplement of 70 pages contains the species which have been discovered within the limits of the work during the intervening twenty-two years. These are about 440 in number; the majority being of a tropical or subtropical cast and from the peninsula of Florida; some are naturalized foreigners, a considerable number from the mountains, a fair number first made known to science by Dr. Chapman himself. The veteran author announces his intention of preparing a final edition in place of this reprint, bringing the Southern Flora up to date. We heartily wish him health and strength to carry this laudable determination into effect, and that he may live to enjoy the fruit of his labors. A. G.

3. *Genera Plantarum.*—Auctoribus G. BENTHAM et J. D. HOOKER. Vol. III, part 2, pp. 447–1248.—This concludes the work, was issued in April last, and copies are now in the hands of American botanists. It should be understood that the work is restricted to Phænogamous Plants, the Cryptogamia being relegated to specialists. That must needs be for the Lower Cryptogamia, and under the circumstances for the higher orders as well,—much as it were to be desired that the Ferns should be elaborated, from an experienced general botanist's point of view, by the venerable senior author of the Genera Plantarum which is now happily completed as to the Phanerogamia. We hope to give some further account of this concluding volume. A. G.

4. *Monographiæ Phanerogamarum.* Auct. ALPHONSO et CASIMIR DECANDOLLE. Vol. IV. March, 1883.—Nearly all the volume is the work of Professor Engler of Kiel, consisting of a very careful re-elaboration of the *Burseraceæ* and the *Anacardiaceæ.* Refining a little on the genera as admitted by DeCandolle and by Bentham and Hooker, Engler restores not only *Lithræa* of Miers, but also *Cotinus* and *Metopium* of old authors. Fifteen plates are well filled with analyses of the genera of these orders. The Monocotyledonous orders are not much advanced in this volume, containing, as it does, only a monograph of the *Pontederiaceæ,* by Solms-Laubach, the descriptive part in twenty-one pages. A. G.

5. *Handbook of Vertebrate Dissection;* by H. NEWELL MARTIN and WM. H. MOALE. Part II, How to Dissect a Bird. 12mo, 174 pp., cuts. Macmillan & Co. New York, 1883.—This handbook contains a detailed account of the zoological relations and anatomy of the domestic pigeon, with full directions for the beginner as to modes of manipulation and what to observe. The index is comprehensive. It will be found to be a very useful manual for laboratory instruction. A. E. V.

6. *Synopsis of the Fishes of North America;* by DAVID S. JORDAN and CHAS. H. GILBERT. Bulletin of U. S. National Museum, No. 16. 8vo, 1018 pp. Washington, 1883.—In this volume

the authors have brought together descriptions of all the families, genera and species, known from North America, both of the marine and fresh-water fishes. The work includes 1340 species, belonging to 487 genera, and 130 families. A large part of the descriptions are original, and when previous ones have been copied, the authors from whom they are taken are properly indicated. The first part of the work was printed in 1879, and the length of time since it was begun has rendered it necessary to print a large appendix, containing corrections and new information of various kinds. A considerable number of new species are included in the work. There is a full table of contents and a copious index. This book will form a convenient and valuable manual of North American fishes. A. E. V.

7. *The Atlantic Right Whales;* by J. B. Holder. Bulletin of the American Museum of Natural History, vol. i, No. 4, three large folded plates and one artotype plate. New York, May, 1883.—In this number Dr. Holder has given a detailed account of several specimens, including both sexes, of the small right whale found off our eastern coasts, but much less frequently now than formerly. The paper is accompanied by several large and good plates, illustrating the external appearance as well as the skeleton. The artotype, showing the skull and whalebone, is excellent. A history of the knowledge of this species, which has formerly been much confused, is also included. A. E. V.

IV. Astronomy.

1. *Draper Astronomical Medal.*—At the recent meeting of the National Academy of Sciences, held at Washington (this volume, p. 400), it was announced that Mrs. Mary A. Draper, widow of Professor Henry Draper, had given in trust to the Academy the sum of six thousand dollars, the income of which is to be used "for the purpose of striking a gold medal, which shall be called the Henry Draper Medal, and shall be of the value of two hundred dollars." This medal is to be awarded not oftener than once in two years, to any person in the United States or elsewhere who shall have made an investigation in astronomical physics worthy, in the opinion of the Academy, of this honor. It is further provided that if the income of the fund shall exceed the amount required for the medal, the surplus may be used to assist investigations by a citizen of the United States, in the department of astronomical physics. This gift by Mrs. Draper is a fitting memorial to Dr. Draper, whose labors in this same field were crowned with so brilliant success.

The Solution of the Pyramid Problem by R. Ballard, C. E. (of Malvern, England). 110 pp. 8vo. 1882. (New York, John Wiley & Sons.) This volume, on the objects and uses of the Pyramids of Egypt, aims to show that they were built as the basis of lines and angles for the Egyptian surveyor, that is, to guide in obtaining the meridian lines, fixing directions, measuring angles, and carrying forward a general and detailed survey of the land, and to remain as a correcter or readjuster of boundaries.

INDEX TO VOLUME XXV.*

* This Index contains the general heads BOTANY, GEOLOGY, MINERALS, OBITUARY, ZOOLOGY, and under each the titles of Articles referring thereto are mentioned.

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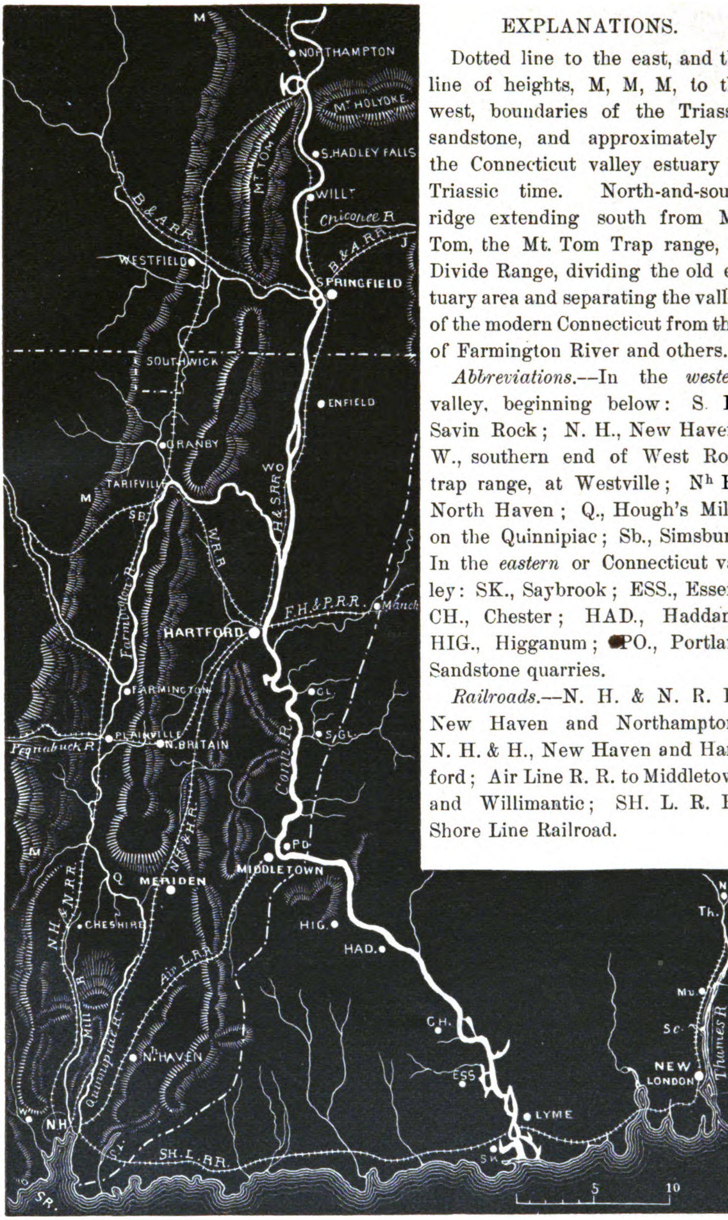

EXPLANATIONS.

Dotted line to the east, and the line of heights, M, M, M, to the west, boundaries of the Triassic sandstone, and approximately of the Connecticut valley estuary of Triassic time. North-and-south ridge extending south from Mt. Tom, the Mt. Tom Trap range, or Divide Range, dividing the old estuary area and separating the valley of the modern Connecticut from that of Farmington River and others.

Abbreviations.—In the *western* valley, beginning below: S. R., Savin Rock; N. H., New Haven; W., southern end of West Rock trap range, at Westville; N^{h} H., North Haven; Q., Hough's Mills, on the Quinnipiac; Sb., Simsbury. In the *eastern* or Connecticut valley: SK., Saybrook; ESS., Essex; CH., Chester; HAD., Haddam; HIG., Higganum; PO., Portland Sandstone quarries.

Railroads.—N. H. & N. R. R., New Haven and Northampton; N. H. & H., New Haven and Hartford; Air Line R. R. to Middletown and Willimantic; SH. L. R. R., Shore Line Railroad.

Map of the Connecticut Valley Region South of Northampton.